SEPTEMBER 5, 1979

A CAHNERS PUBLICATION

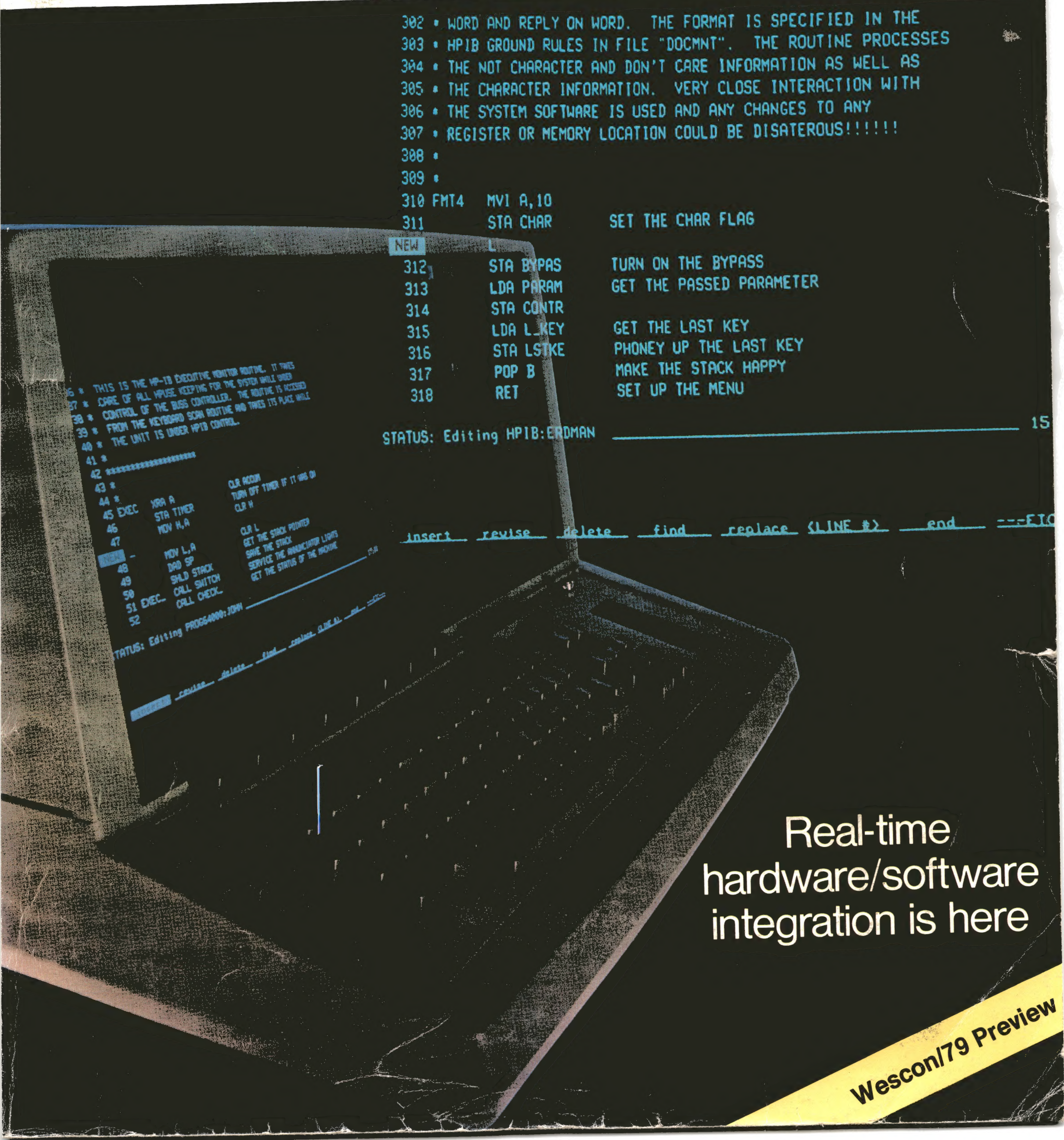
EDN

EXCLUSIVELY FOR DESIGNERS AND DESIGN MANAGERS IN ELECTRONICS

Special Report: EMI shielding and protective components

Dual variable op-amp IC expands design horizons

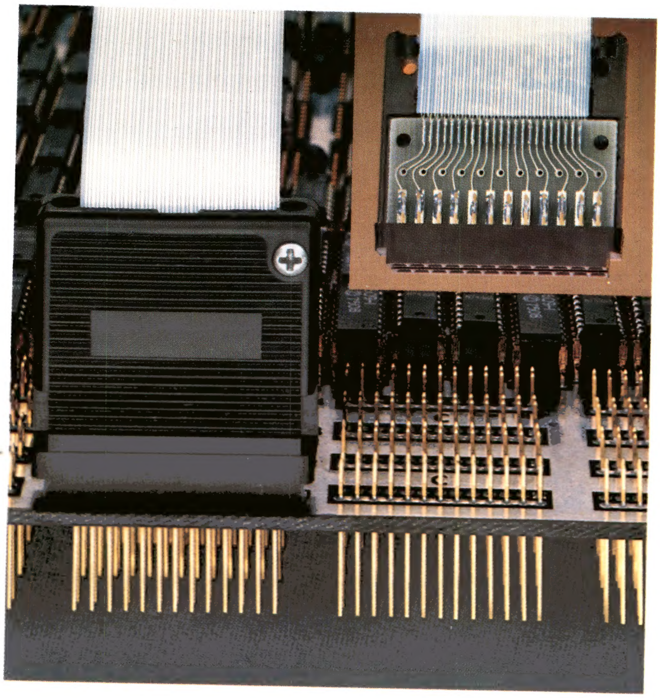
Triac-based circuit conserves motor power



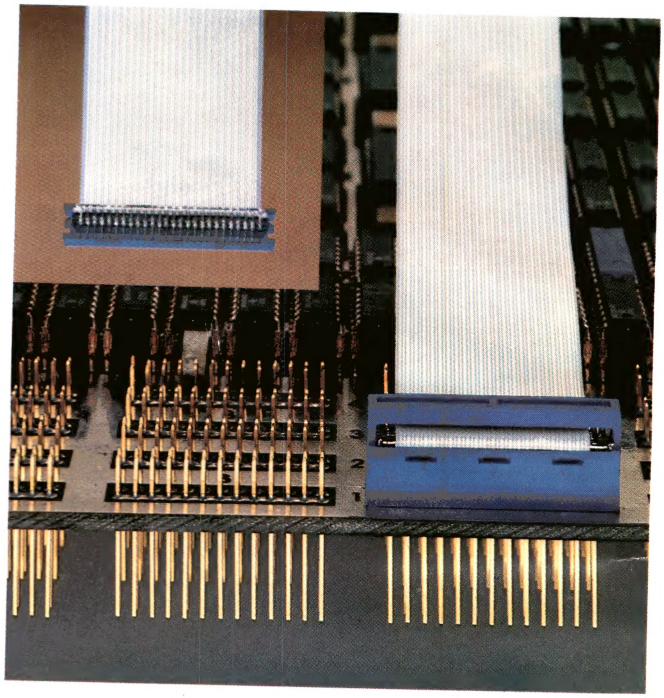
Real-time hardware/software integration is here

Wescon/79 Preview

Berg's TLC* connector terminates transmission line cable without a paddleboard.



Paddleboard assembly–the slow way.



"TLC" connector–the fast way.

Assembly time and the cost of terminating transmission line cable are significantly reduced with Berg's unique "TLC" connector system. Completely eliminating the need for a paddleboard, the "TLC" connector reduces cable assembly time to seconds.

The connector's compact size provides greater signal fidelity and facilitates high-density packaging.

"TLC" connectors terminate any cable with signals on 0.050″ centers. The ground wires are commoned on the buss bar allowing use of a wide range of cable designs with a variety of ground centers and diameters. Pre-deposited solder on the buss bar and signal tabs allow for mass reflow. This produces higher yields and further reduces assembly cost.

The "TLC" design uses Berg's proprietary PV* receptacle, a connector of proven reliability for over a decade in data processing applications. The dual-metal construction of the "PV" provides a high normal force to assure highly reliable mechanical and electrical performance.

"TLC" connectors mate with 0.025″ pins or standard Berg headers on 0.100″ grid to form a complete interconnection system.

Look to Berg for innovative research and development to meet your connector needs, today and in the future. For a brochure describing the "TLC" system, write or call:

The Du Pont Company, Berg Electronics Division, New Cumberland, Pennsylvania 17070.
Telephone: (717) 938-6711.

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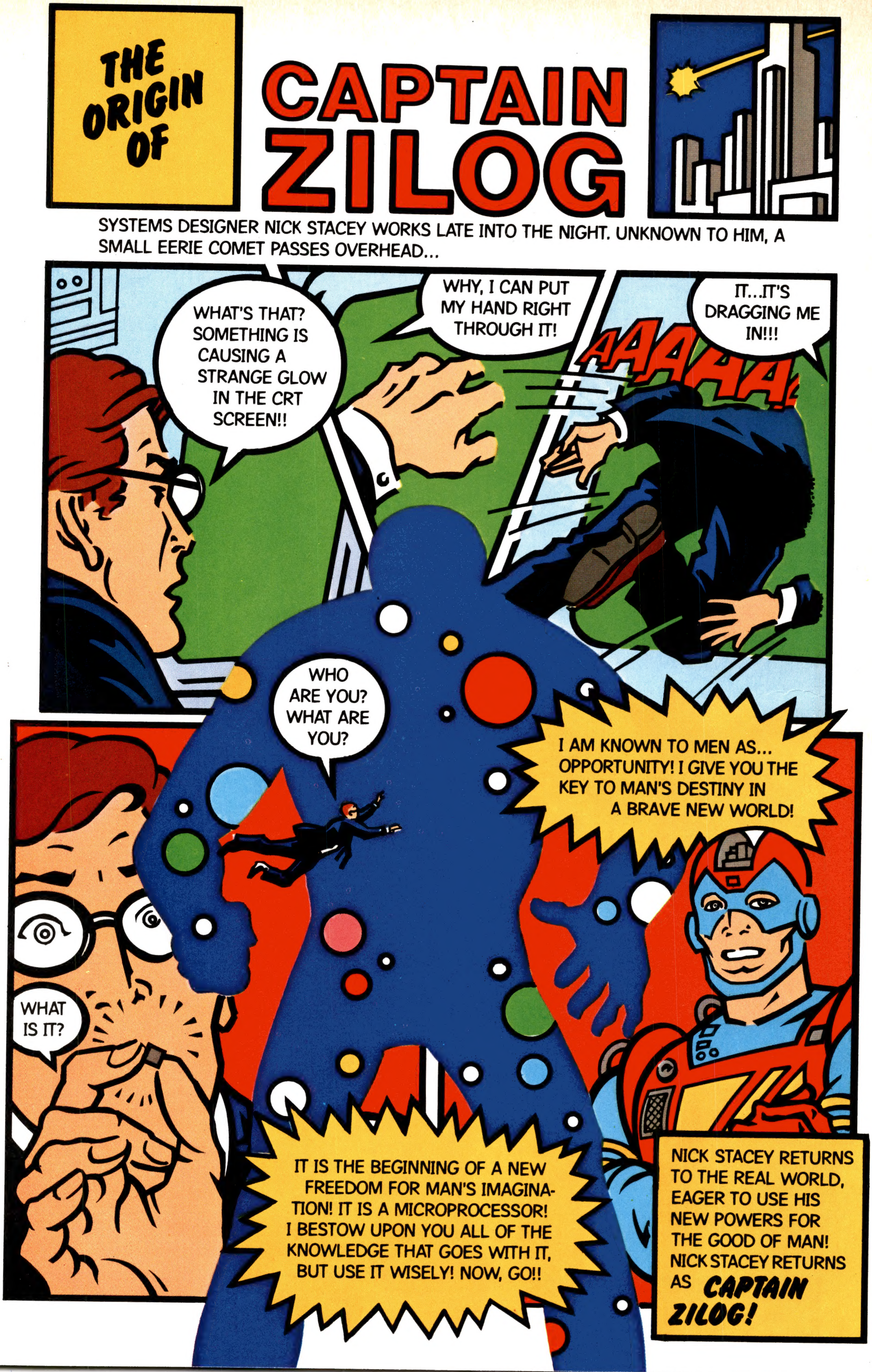
No.1
CAPTAIN
ZILOG!
WESCON/79
COLLECTOR'S
EDITION



THE ORIGIN OF
CAPTAIN ZILOG
SYSTEMS DESIGNER NICK STACEY WORKS LATE INTO THE NIGHT. UNKNOWN TO HIM, A SMALL EERIE COMET PASSES OVERHEAD...
WHAT'S THAT? SOMETHING IS CAUSING A STRANGE GLOW IN THE CRT SCREEN!!
WHY, I CAN PUT MY HAND RIGHT THROUGH IT!
IT...IT'S DRAGGING ME IN!!!
AAAAAA!
WHO ARE YOU? WHAT ARE YOU?
I AM KNOWN TO MEN AS... OPPORTUNITY! I GIVE YOU THE KEY TO MAN'S DESTINY IN A BRAVE NEW WORLD!
WHAT IS IT?
IT IS THE BEGINNING OF A NEW FREEDOM FOR MAN'S IMAGINATION! IT IS A MICROPROCESSOR! I BESTOW UPON YOU ALL OF THE KNOWLEDGE THAT GOES WITH IT, BUT USE IT WISELY! NOW, GO!!
NICK STACEY RETURNS TO THE REAL WORLD, EAGER TO USE HIS NEW POWERS FOR THE GOOD OF MAN! NICK STACEY RETURNS AS CAPTAIN ZILOG!


CAPTAIN ZILOG!
THE USUAL MIDDAY HUSTLE AND BUSTLE OF DOWNTOWN CITYVILLE IS ABOUT TO BE INTERRUPTED BY A STRANGE VISITOR! TALK ABOUT HIDING THE KEY TO THE CITY!!
CITIZENS OF CITYVILLE!! I, DR. DIABOLICUS, AM NOW YOUR SUPREME MASTER!!
AMID THE STARTLED CROWD ARE SYSTEMS DESIGNER NICK STACEY, AND HIS FRIEND, ANNE...
LEAPIN' LOGIC, ANNE! LOOK AT THAT THING!
PROBABLY JUST A PUBLICITY GIMMICK...
"THE DOOM OF DR. D!"

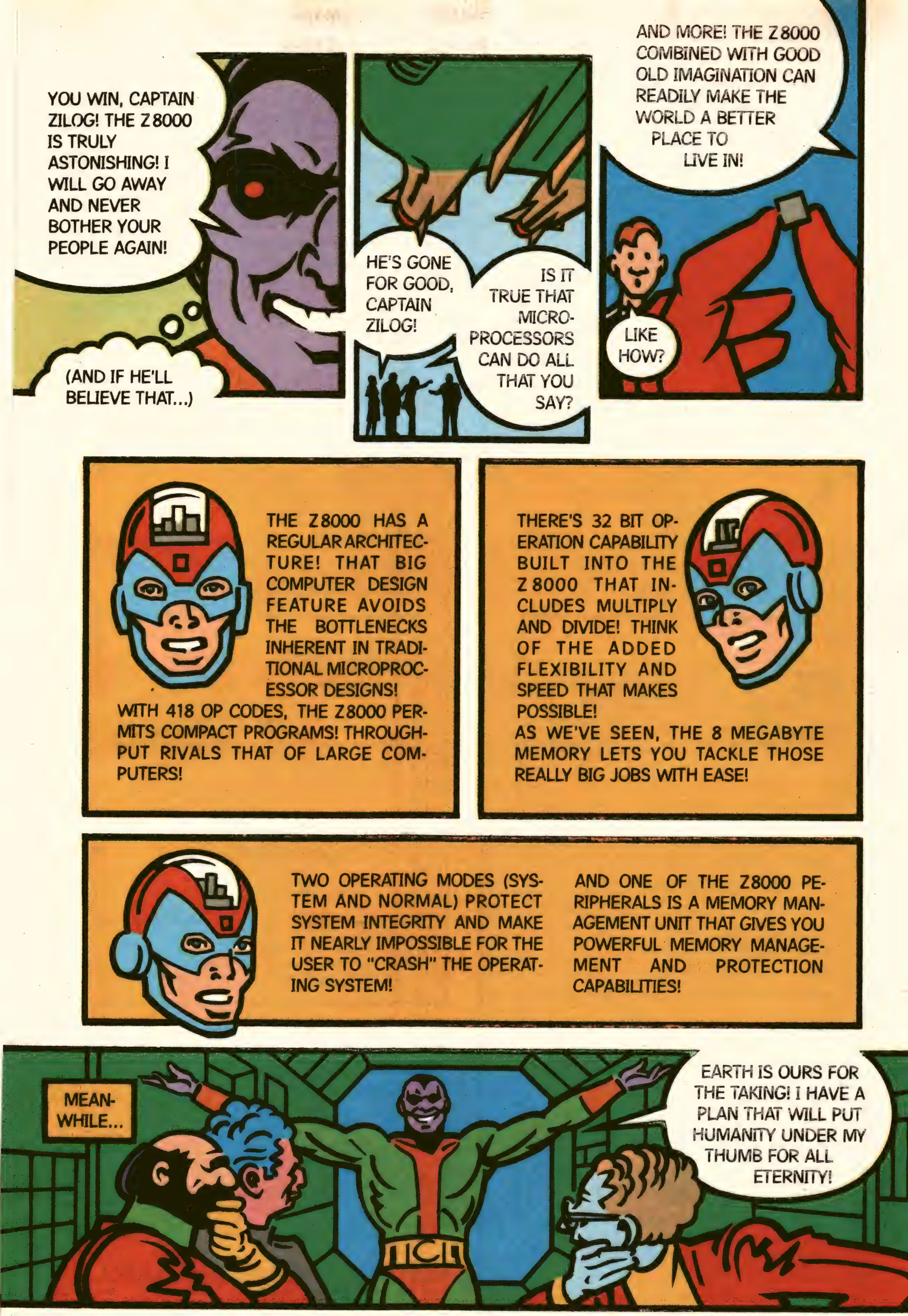

HEY! WHERE'D HE GO?
IT'S AS BIG AS A SKYSCRAPER, NICK!
I HATE TO LEAVE ANNE ALONE, BUT THIS SITUATION CALLS FOR CAPTAIN ZILOG!
LE BYTE RESTAURAN
MOMENTS LATER, IN THE REST ROOM OF A SWANK NEIGHBORHOOD RESTAURANT...
THE...FIRE-WORKS...HAVE JUST...
BEGUN!
SPROUTING SIX MECHANICAL LEGS, THE STRANGE SPACECRAFT SETTLES TO EARTH LIKE A GIANT INSECT...
THAT SPACESHIP THING IS LANDING!
THERE'S CAPTAIN ZILOG! HE'LL KNOW WHAT TO DO!
MY LOYAL SUBJECTS!! I AM DIABOLICUS, CONQUEROR OF ALL TIME AND SPACE! (I ALSO HAVE A LITTLE MAIL-ORDER COMPUTER REPAIR SCHOOL ON THE SIDE IN SANTA CLARA!)
MY SATELLITE STATION ORBITS YOUR PLANET AT THIS VERY MOMENT! IT AND THIS MACHINE ARE CONTROLLED BY THE LARGEST AND MOST COMPLEX COMPUTERS IN THE UNIVERSE!!


BEFORE YOU TAKE OVER THE WORLD, DIABOLICUS, YOU BETTER REALIZE THAT BIG COMPUTER SET UP YOU'RE MISUSING DOESN'T ALWAYS MEAN YOU'RE IN CONTROL!
WHAT?? WHO ARE YOU?
IT'S TRUE THERE ARE CERTAIN JOBS THAT LARGE COMPUTERS DO BEST, BUT THIS LITTLE SILICON CHIP I'M HOLDING IS THE ZILOG Z8000!!
IT'S THE STATE OF THE ART OF MICROPROCESSORS, AND I'M WILLING TO BET IT'LL GIVE YOU A RUN FOR YOUR MONEY!
ZILOG'S THE NAME, AND MICROPROCESSING'S MY GAME!
THAT LITTLE THING?? DON'T MAKE ME LAUGH!!
THANKS TO THE ZILOG MICROPROCESSOR'S ADVANTAGE OF SHORT DESIGN TIME, CAPTAIN ZILOG BUILDS A SYSTEM AROUND THE Z8000 AT LIGHTNING SPEED!
TECHNICIANS!! ACTIVATE I/O CHANNELS!! DESTROY THAT BUILD--


ZZZZAAP!
IT'S A FACT OF LIFE, DOC! THE CLEVER ARCHITECTURE OF MY Z8000 MAKES ME FASTER ON THE DRAW, AS THE PROBLEMS GET TOUGHER!!
AND THANKS TO THE ZILOG Z8000--AND THE ENGINEERS WHO MADE IT POSSIBLE!
THANKS TO CAPTAIN ZILOG!
IT'S GOING AWAY!
SHORTLY AFTERWARDS, DIABOLICUS GATHERS HIS HENCHMEN IN THE WAR ROOM OF HIS SATELLITE...
THESE EARTHLINGS ARE MORE CLEVER THAN I THOUGHT! ESPECIALLY THIS ZILOG FELLOW! HE WORKS MAGIC* WITH A LITTLE SQUARE OF SILICON!
NO, BOTTLENECK! I'LL HAVE TO DEAL WITH CAPTAIN ZILOG MYSELF!!
LEMME AT 'IM, BOSS! I'LL BOTTLENECK HIS SYSTEM WHERE IT'LL REALLY HURT!
*IT'S NOT MAGIC, READERS! WITH DUAL ENVIRONMENTS, 418 OP CODES, AND ITS UNPARALLELED DEGREE OF REGULAR ARCHITECTURE, THE Z8000 IS THE MOST SOPHISTICATED MICROPROCESSOR AVAILABLE!

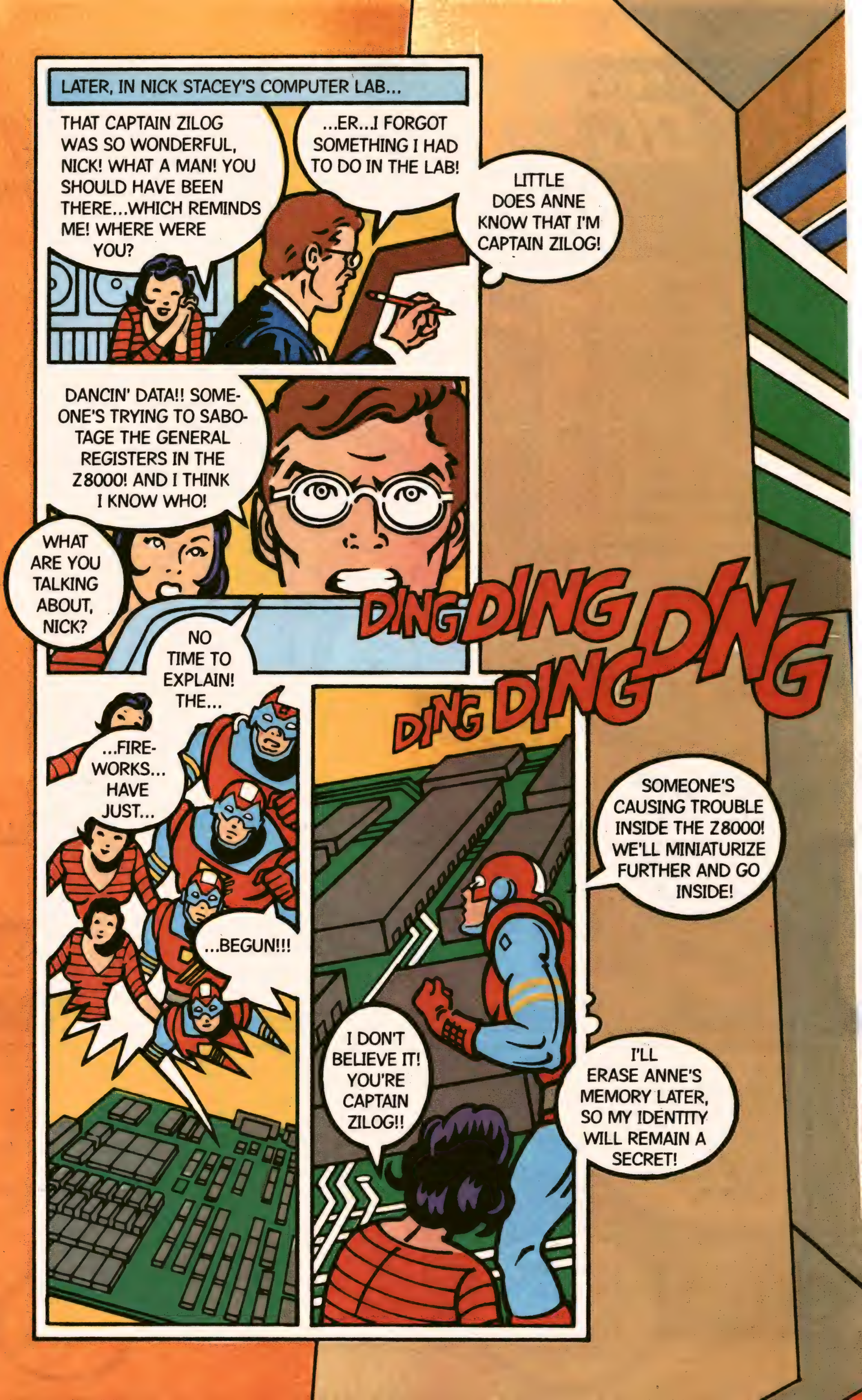
LATER...
DO NOT FEAR ME, EARTHLINGS! I ONLY WISH TO SPEAK TO CAPTAIN ZILOG!
GIVE UP, CAPTAIN ZILOG! YOU CAN'T POSSIBLY WIN, EVEN WITH YOUR MAGIC CHIP YOU CALL THE Z8000!
STICK IT IN YOUR INDEX REGISTER, DIABOLICUS!
THEN BEHOLD THE WRATH OF...
DIABOLICUS!
IS YOUR EAGER LITTLE Z8000 ABLE TO TELL YOU WHICH OF US IS ME?


IN A BLINK OF AN EYE, CAPTAIN ZILOG CHOOSES THE REAL CULPRIT!
EASY, BORON BREATH! WITH AN ADDRESS SPACE OF EIGHT MEGABYTES, THE ZILOG Z8000 MICROPROCESSOR IN MY COMPUTER BELT WAS ABLE TO SPOT YOU AMONG THOSE MILLIONS OF FAKES BEFORE YOU COULD SAY, "CUPERTINO, CALIFORNIA"!
C
ARRESTING ME WON'T SAVE YOU, ZILOG! I'VE JUST MENTALLY INSTRUCTED MY ALLIES—WASTE, INEFFICIENCY, AND OUTMODED THINKING—TO SABOTAGE THE NERVE CENTERS OF YOUR PUNY CIVILIZATION!
YOUR ENTIRE CITY IS ABOUT TO GRIND TO A PITIFUL HALT! HAHAHAHA!
SCH
AS THE CITY'S PRODUCTION, TRANSPORTATION, AND COMMUNICATIONS SYSTEMS BEGIN TO FALTER, CAPTAIN ZILOG FLASHES FROM MACHINE TO MACHINE, SHOUTING HIS MAGIC WORD, "IMAGINE!", AND EACH IS INSTANTLY CONVERTED TO MICROCOMPUTERIZATION!
WHEN YOU GIVE MACHINES THE POWER TO PROCESS LARGE QUANTITIES OF DATA IN REAL TIME, THEY NOT ONLY RUN MORE EFFICIENTLY, THEY CAN DO THINGS THEY NEVER COULD BEFORE!
ZILOG'S Z8000 MAKES THAT POWER BOTH AFFORDABLE AND USABLE, WHERE OTHER COMPUTERS WOULD BE JUST TOO BIG!!
IMAGINE!



BE SURE TO READ PART TWO IN THIS ISSUE: ***Battle Beneath the ARCHITECTURE!***

CAPTAIN ZILOG! "BATTLE BENEATH THE ARCHITECTURE!"
IN THE ROYAL CHAMBER OF HIS SATELLITE, DR. DIABOLICUS LAUNCHES A NEW PLAN WITH HIS HENCHMEN—BOTTLE-NECK, POWER STEALER, CRASHER, SCRAMBLER, SCORCHER, AND KLUGER! IT JUST GOES TO SHOW YOU: YOU CAN'T KEEP A GOOD SCOURGE OF THE UNIVERSE DOWN!!
MY MISTAKE WAS IN ASSUMING THAT CAPTAIN ZILOG IS AT THE BOTTOM OF OUR PROBLEMS!
BUT METHINKS THIS ACCURSED Z8000 IS THE SOURCE OF HIS POWER!
SO, WHUT'S THUH PLAN, BOSS?
YEAH! DO WE GET TO SHIFT N' ROTATE THAT MICRO MENACE?
IN DUE TIME! FIRST OUR MINIATURIZATION SYSTEM MUST SHRINK US DOWN TO MICROSCOPIC SIZE, AND TELEPORT US TO CAPTAIN ZILOG'S COMPUTER!
FROM THERE, WE'LL WEASEL OUR WAY INSIDE THE Z8000 ARCHI-TECTURE!!
THEN WE SABOTAGE IT!! SCORCHER! MAN YOUR TORCHES! BOT-TLENECK! GATHER YOUR MEN! CRASHER! GET SET FOR SOME FUN! SCRAMBLER! GET SET FOR SOME SILICON SMASHING!!
TAKE NO PRISONERS!!


LATER, IN NICK STACEY'S COMPUTER LAB...
THAT CAPTAIN ZILOG WAS SO WONDERFUL, NICK! WHAT A MAN! YOU SHOULD HAVE BEEN THERE...WHICH REMINDS ME! WHERE WERE YOU?
...ER...I FORGOT SOMETHING I HAD TO DO IN THE LAB!
LITTLE DOES ANNE KNOW THAT I'M CAPTAIN ZILOG!
DANCIN' DATA!! SOME-ONE'S TRYING TO SABO-TAGE THE GENERAL REGISTERS IN THE Z8000! AND I THINK I KNOW WHO!
WHAT ARE YOU TALKING ABOUT, NICK?
DING DING DING
DING DING DING
NO TIME TO EXPLAIN! THE...
...FIRE-WORKS... HAVE JUST...
...BEGUN!!!
SOMEONE'S CAUSING TROUBLE INSIDE THE Z8000! WE'LL MINIATURIZE FURTHER AND GO INSIDE!
I DON'T BELIEVE IT! YOU'RE CAPTAIN ZILOG!!
I'LL ERASE ANNE'S MEMORY LATER, SO MY IDENTITY WILL REMAIN A SECRET!

BYTE-SEEING TOURS
BIT, NIBBLE & WORD STRING EXCURSIONS
ANNE AND CAPTAIN ZILOG SUDDENLY FIND THEMSELVES INSIDE THE ARCHITECTURE OF THE Z8000! THEY ARE OVERWHELMED BY ITS INCREDIBLE VASTNESS...
WE CAN TAKE ONE OF THOSE CORRIDORS TO THE GENERAL REGISTERS!


WHO ARE THOSE PEOPLE?
WHY, THEY'RE QUEUED UP FOR A Z-BUS, OF COURSE!
MEANWHILE, NEAR THE GENERAL REGISTERS...
ACCUMULATOR
STACK POINTER
INDEX
SOURCE OPERAND
DESTROY THAT STACK POINTER!
ZAP
STACK POINTER
INDEX
STACK POINTER
HAHAHA! THIS'LL DISABLE YOUR PRECIOUS Z8000!
HOLY COW, BOSS! DIS BABY CAN USE ANY OF ITS REGISTERS AS A STACK POINTER!
NONE OF THE REGISTERS ARE DESIG-NATED! THEY'RE ALL GENERAL!
CRASHER! ARE YOU READY TO MOVE IN AND CRASH THE PARTY?
CRASHER MAKES HIS WAY ALONG ONE OF THE Z8000'S THREE INTERRUPT INPUTS...
READY, BOSS! I'LL GET 'EM FROM BEHIND!


AS CRASHER STEPS ON THE INTERRUPT INPUT CONTACT, HE CAUSES THE INTERRUPT STRUCTURE TO SWITCH TO THE OPERATING SYSTEM!
YEOW!
BRZZZT
TO SYSTEM STACK
WHAT TH' #%*#¢??
YOU CAN KISS YOUR MEN GOOD BYE, THANKS TO WHOEVER YOU HAD FOOLING AROUND WITH THE INTERRUPT INPUTS!
THWUKK
PROGRAM STATUS REGISTERS
YOU'RE NEXT, 'BOLICUS BABY!!
I WOULDN'T DO THAT IF I WERE YOU, ZILOG!!
C'MON, BOSS! WE CAN ESCAPE WITH THE GIRL TO THE OPERATING SYSTEM, AND DO SOME DAMAGE THERE!!


GIVE UP, BOTTLENECK! BECAUSE OF THE Z8000'S MULTIPLE ADDRESSING MODES, GENERAL PURPOSE REGISTERS, RICH INSTRUCTION SET, ABUNDANT RESOURCES, AND REGULARITY...YOU DON'T STAND A CHANCE!!
WITH ANNE AS HOSTAGE, DR. DIABOLICUS AND BOTTLENECK TRY DOOR AFTER DOOR, ONLY TO FIND...
HUH? NONE OF THESE DOORS HAVE ANY WAY OF BEING OPENED!
AUTHOR PERSONN ONLY
THAT'S BECAUSE THE Z8000 HAS PROTECTED DUAL ENVIRONMENT! THERE'S NO WAY FOR A HARDWARE BRAIN LIKE YOURSELF TO TAMPER WITH THE OPERATING SYSTEM!
THIS WAY MEN!
JUST WHAT DO THESE EIGHT-BIT REFUGEES THINK THEY'RE DOING?
HEY!! IS IT MY IMAGINATION, OR ARE WE...
.....GROWING!!!
IF YOU HAD ANY IMAGINATION, YOU WOULDN'T BE IN THIS FIX!


THANKS TO THE VERSATILITY AND LIGHTNING SPEED OF THE Z8000 INSTRUCTION SET, I WAS ABLE TO TELL THESE GUYS TO CANCEL YOUR MINIATURIZATION FIELD IN JUST A FEW, WELL-CHOSEN OP CODES!*
*CAPTAIN ZILOG HAD 418 TO CHOOSE FROM!
YOU'VE BEATEN ME, CAPTAIN ZILOG! THE Z8000 IS SOMETHING I WAS NOT PREPARED TO DEAL WITH! I HAVE OTHER PLANETS TO CONQUER THAT ARE FAR LESS TROUBLE THAN THIS ONE!
WE GOTTA TELEPORT BACK TO THE SATELLITE IMMEDIATELY, BOSS, OR WE'LL BE CRUSHED!

Written, designed, and illustrated by Lou Brooks. Penciled by Joe Kubert.


FANS!
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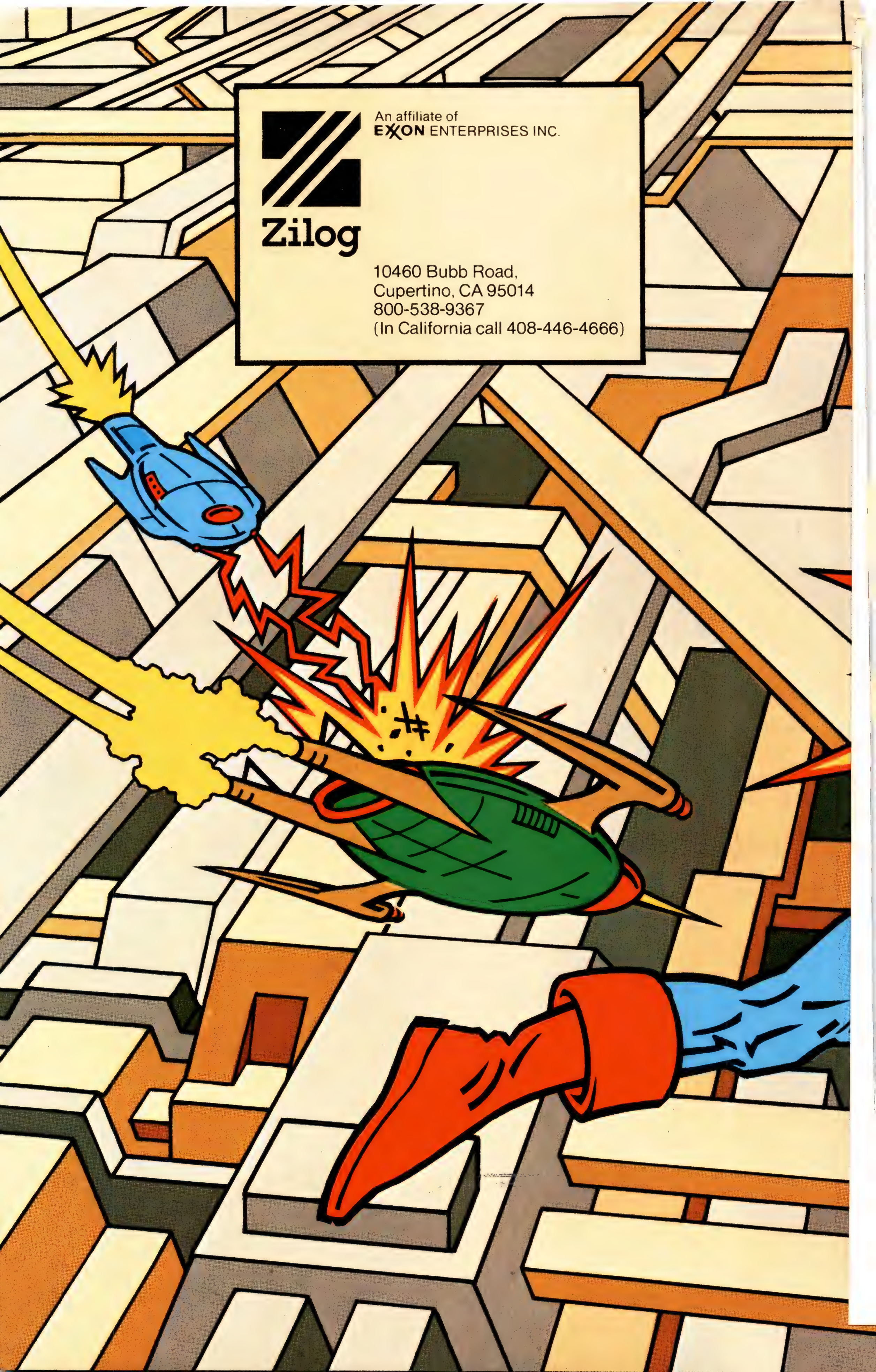

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SEPTEMBER 5, 1979 ● VOLUME 24, NUMBER 16 ● EXCLUSIVELY FOR DESIGNERS AND DESIGN MANAGERS IN ELECTRONICS

Probes and test cells *simplify EMI measurements (pg 51).*

Wescon/79 *blazes trails for new designs in electronics (pg 120).*

On the cover: *The newest mP development systems help prevent disastrous design slowdowns — and even disaterous (!) ones (pgs 99, 179, 227). (Photo of the HP64000 courtesy Hewlett-Packard Co)*

DESIGN FEATURES

TECHNOLOGY NEWS

NEW PRODUCTS

DEPARTMENTS

CP BPA ABP

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the challenge leadership.

See Us at WESCON
Booth Nos. 110-118

TRW CINCH CONNECTORS

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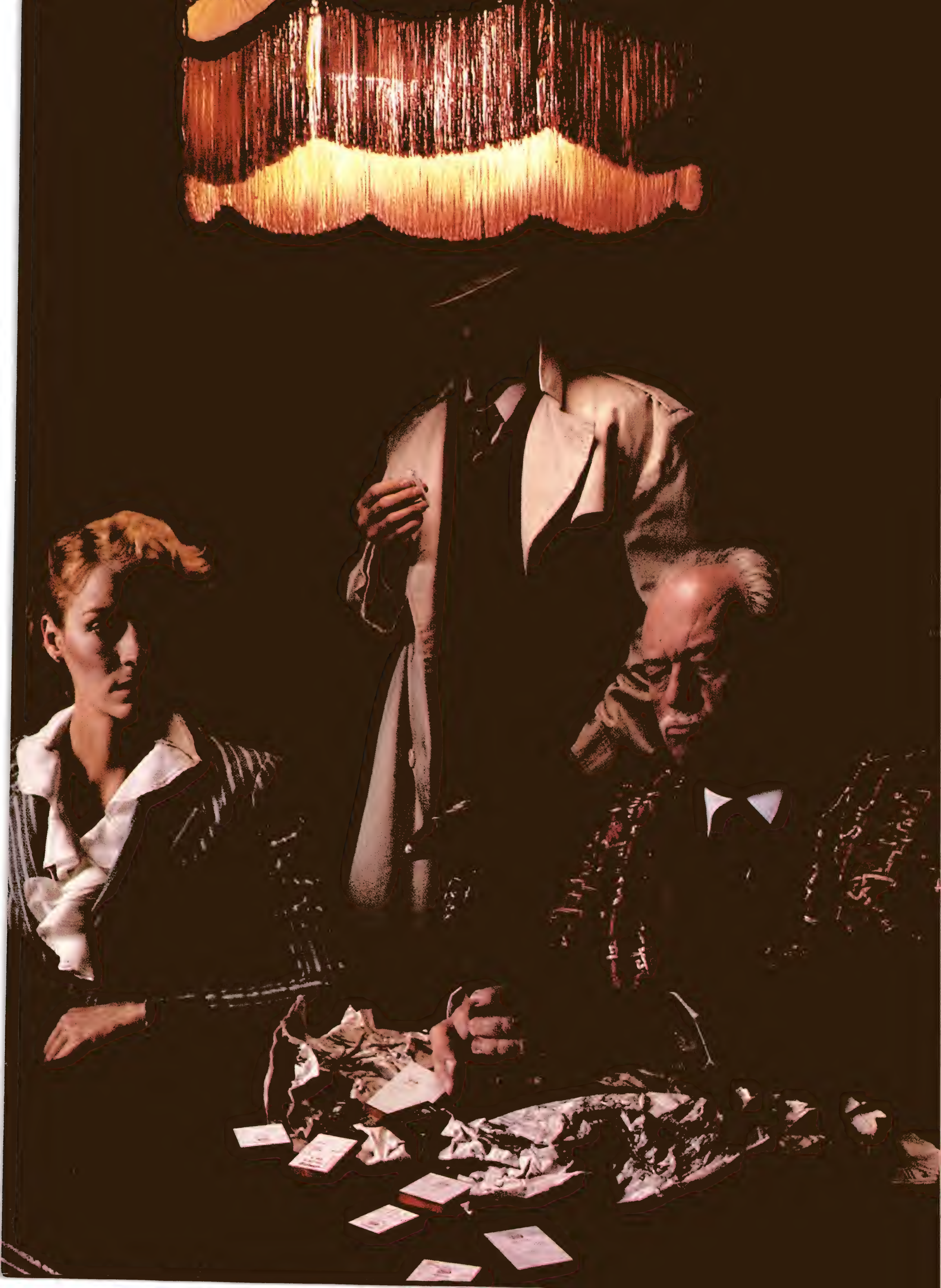

The TREASURE of the BLACKBIRD

A Taut Tale of The Man from Intech in Which He Gets The Bird and Saves The Treasure of the Intechs.

It was foggy. And I was inching along a narrow ledge outside the Mariposa Hotel seven stories above traffic. I knew I had to hurry. The fog was coming in from The Bay. As I reached I. M. Grossman's window, I drew my .45 automatic. I peered through the curtains. They were there—the old goat Grossman and Hortense O'Hara. *Damn*, I thought, *I haven't a minute to spare*. They'd opened The Bird.

"Okay," I growled as I clamored through the window, waving my trusty heater, "nobody move."

"What is the meaning of this outrage, sir?" Grossman rumbled from deep in his throat.

"Just sit tight, old man," I warned.

"My dear boy," Grossman replied, "there must be some mistake. By gad, I was searching for a lost treasure in diamonds, rubies and emeralds. Instead, I find a bird filled with strange little boxes."

"Let angel-face here enlighten you," I answered menacingly. I pointed the gun at Miss O'Hara's pretty head, "Go on, sweetheart. *Tell him*."

Hortense jumped as I jerked the automatic in her direction. Her violet eyes widened with fear. "Why, mercy me, I haven't the foggiest..."

"Shaddap," I snapped. "She tricked you, Pops. Fed you a tall tale about a treasure bird of the Aztecs. She knew you'd open it and figure you'd been swindled. She was gonna offer to take the stuff off your hands. We both been conned..."

"Gentlemen, please..." Hortense pleaded.

I cocked the trigger. "Tell him, precious."

Hortense slumped in her chair. "The Black Bird," she began, "really holds the world's largest collection of A/D and D/A data converters. They're all self-contained, ready-to-operate, low profile modules, ranging in price from $53.00 to $1850.00. The total collection offers a range of resolution from 4 bits through 18 bits."

"You're good, angel," I piped in, "you're really good." I picked one of the Intech gems and held it up. "School's in session. What's this?"

Hortense bit her lip, then answered: "An A-866-H-12, 10 MHz deglitched 12-bit DAC."

"My, my," I said with mock amazement. I grabbed another box at random. "And this?"

Hortense's eyes flashed with excitement. "That's the new 16-bit Model A-858-16 A/D data converter that's microprocessor compatible and is user programmable for several input ranges and output codes using a single dip switch."

Just then Lt. Flaherty and the boys in blue burst through the hall door.

"Take 'em downtown," I said, slipping my roscoe back into its holster.

"But lambykins," Hortense cooed as she sidled up next to me. "You're just jesting, right?"

"Sorry, kiddo," I replied. "But I don't play patsy for nobody. I know I'll never find another dame who knows as much about data converters. But I'll keep looking. So long."

Hortense refused to look at me as the elevator took her down.

I called out, "If Intech puts out a new DAC, I'll send a data sheet to the Big House so's you won't lose touch with the market."

Hortense yelled something back. Fortunately, I couldn't hear what it was.

There are no mysteries in data conversion that can't be solved quickly and economically by *The Man from Intech*. Call or write him today for more detailed information at Intech/Function Modules, Inc., 282 Brokaw Road, Santa Clara, CA 95050. (408) 244-0500.

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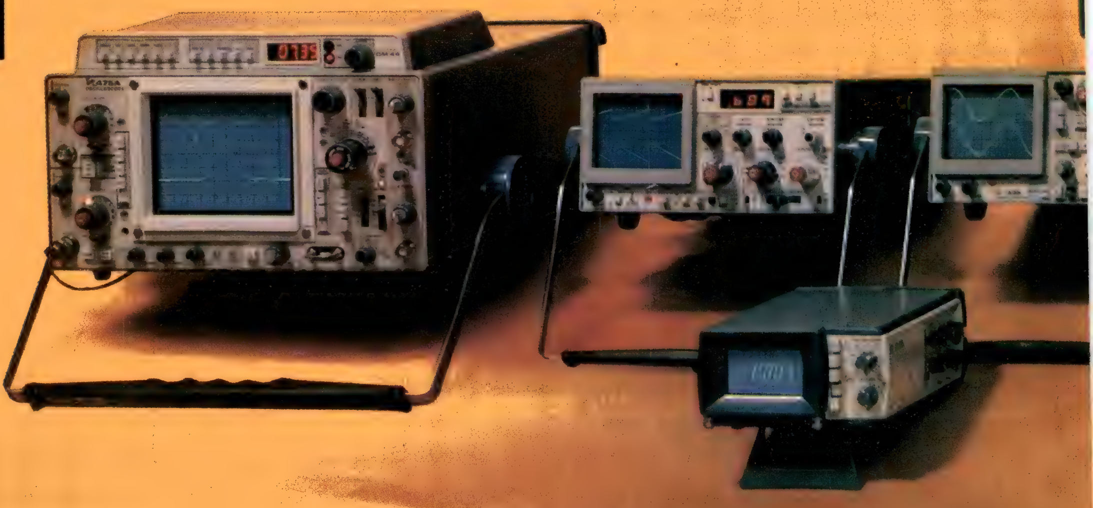
We're going places



scope meets

	Product	Bw	Dual Trace	Delayed Sweep	Fastest Sweep Rate	Other Special Features	Price*
Storage Models	466	100 MHz @ 5 mV/div	yes	yes	5 ns/div	3000 div/μs stored writing speed	$5550
	464	100 MHz @ 5 mV/div	yes	yes	5 ns/div	110 div/μs stored writing speed	4500
	434	25 MHz @ 10 mV/div	yes		20 ns/div	Split-screen storage	3585
	314	10 MHz @ 1 mV/div	yes		100 ns/div	Only 10.5 lbs (4.8 kg)	2725
	214	500 kHz @ 10 mV/div	yes		1 μs/div	Only 3.5 lbs (1.6 kg)	1650
	T912	10 MHz @ 2 mV/div	yes		50 ns/div	Low-cost bistable storage	1545
Nonstorage Models	485	350 MHz @ 5 mV/div	yes	yes	1 ns/div	Widest bw in a portable	5870
	475A	250 MHz @ 5 mV/div	yes	yes	1 ns/div	High-performance 250-MHz portable	3925
	475	200 MHz @ 2 mV/div	yes	yes	1 ns/div	Highest gain-bw in a portable	3550
	465	100 MHz @ 5 mV/div	yes	yes	5 ns/div	Cost effective for 100-MHz bw	2495
	465M	100 MHz @ 5 mV/div	yes	yes	5 ns/div	Triservice standard 100-MHz scope	2700
	455	50 MHz @ 5 mV/div	yes	yes	5 ns/div	Cost effective for 50-MHz bw	2155
	335	35 MHz @ 10 mV/div	yes	yes	20 ns/div	Only 10.5 lbs (4.8 kg)	2230
	305	5 MHz @ 5 mV/div	yes		0.1 μs/div	Autoranging DMM	1780
	221	5 MHz @ 5 mV/div			100 ns/div	Only 3.5 lbs (1.6 kg)	1225
	213	1 MHz @ 20 mV/div			400 ns/div	DMM/Oscilloscope @ 3.7 lbs (1.7 kg)	1675
	212	500 kHz @ 10 mV/div	yes		1 μs/div	Low cost for dual trace & battery	1250
	T935A	35 MHz @ 2 mV/div	yes	yes	10 ns/div	Delayed sweep and differential	1535
	T932A	35 MHz @ 2 mV/div	yes		10 ns/div	Variable trigger-holdoff and differential	1245
	T922	15 MHz @ 2mV/div	yes		20 ns/div	Low-cost dual-trace scope	975
	T922R	15 MHz @ 2mV/div	yes		20 ns/div	Rackmount version of T922	1345
	T921	15 MHz @ 2mV/div			20 ns/div	Lowest-cost TEKTRONIX Portable	795
Time Interval Readout	DM44	Optional, factory-installed, direct numerical readout of time intervals and DMM functions for the 464, 465, 466, 475 and 475A					445

*U.S. sales prices are F.O.B. Beaverton, OR. For price and availablity outside the United States, please contact the nearest Tektronix Field Office, Distributor or Representative. Prices are subject to change without notice.

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Signals & Noise

More on counters

Dear Editor:
Richard Nelson's article, "Low-frequency crystal oscillators present measurement challenges" (June 5, pg 131), performs a useful service in advising that conventional "cycle-counting" electronic counters have inadequate measurement resolution in low-frequency crystal measurements. However, several other counters should be added to his list of recommended models.

One is Hewlett-Packard's 5315A universal counter, which is by far the lowest priced model ($800) that can measure period and invert the reading for direct frequency readout ("reciprocal taking"). It provides at least 7-digit resolution (±0.0001%) for inputs from 1 Hz to 100 MHz—an excellent value for many crystal-oscillator testing applications.

If more accuracy is needed, H-P's Model 5345A ($4500), which Mr Nelson mentioned, provides 9-digit resolution in 1 sec. And for even higher resolution requirements, there's the HP 5370A universal time-interval counter ($6500), providing 11-digit resolution in 1 sec. These latter two counters are also reciprocal-taking units.

Sincerely,
Tom Nawalinski
Hewlett-Packard Co
Santa Clara, CA

For the birds

Dear Editor:
I would like to solicit ideas from EDN readers on how to develop an accurate bird-census technique for counting large numbers of blackbirds or starlings in a roost (a congregating area). Although this measurement has perplexed the US Fish and Wildlife Service for a number of years, no monitoring system has yet been developed.

Blackbird and starling roosts occur in dense woods or cattail marshes and range in size from less than 1 to more than 100 acres. The number using a roost can range from a few hundred to several million. The birds arrive at these roosts at dusk, either in large swirling masses, in long ribbon-like flight lines or in

For more information, Circle No 8

steady streams which are often half a mile wide (see photo). They remain dormant at night unless disturbed. At dawn there is a raucous period of singing and shifting before the birds depart for their feeding areas in ribbon-like flight lines. Arrivals and departures from the roost can take more than 45 min and often occur in several flight lines.

Possible ideas for remote-sensing devices include photographic techniques, infrared imagery, weight-measuring systems, sound-level measurements, radar scattering or low-light-level TV. Please send your ideas to A Lawrence Kolz, Electrical Engineer, US Fish and Wildlife Service, Bldg 16, Federal Center, Denver, CO 80225.

Sincerely,
A L Kolz

Inadvertently omitted

Dear Editor:

We read with interest EDN's June 5 article entitled "Low-frequency spectrum analyzers simplify audio measurements" (pgs 107-114). We were disappointed, however, to find that Nicolet Scientific was left out of the article, particularly because we believe we sell more spectrum analyzers than a combination of most of the companies the author listed in his article.

Sincerely yours,
Richard S Rothschild
VP, Marketing
Nicolet Scientific Corp
Northvale, NJ

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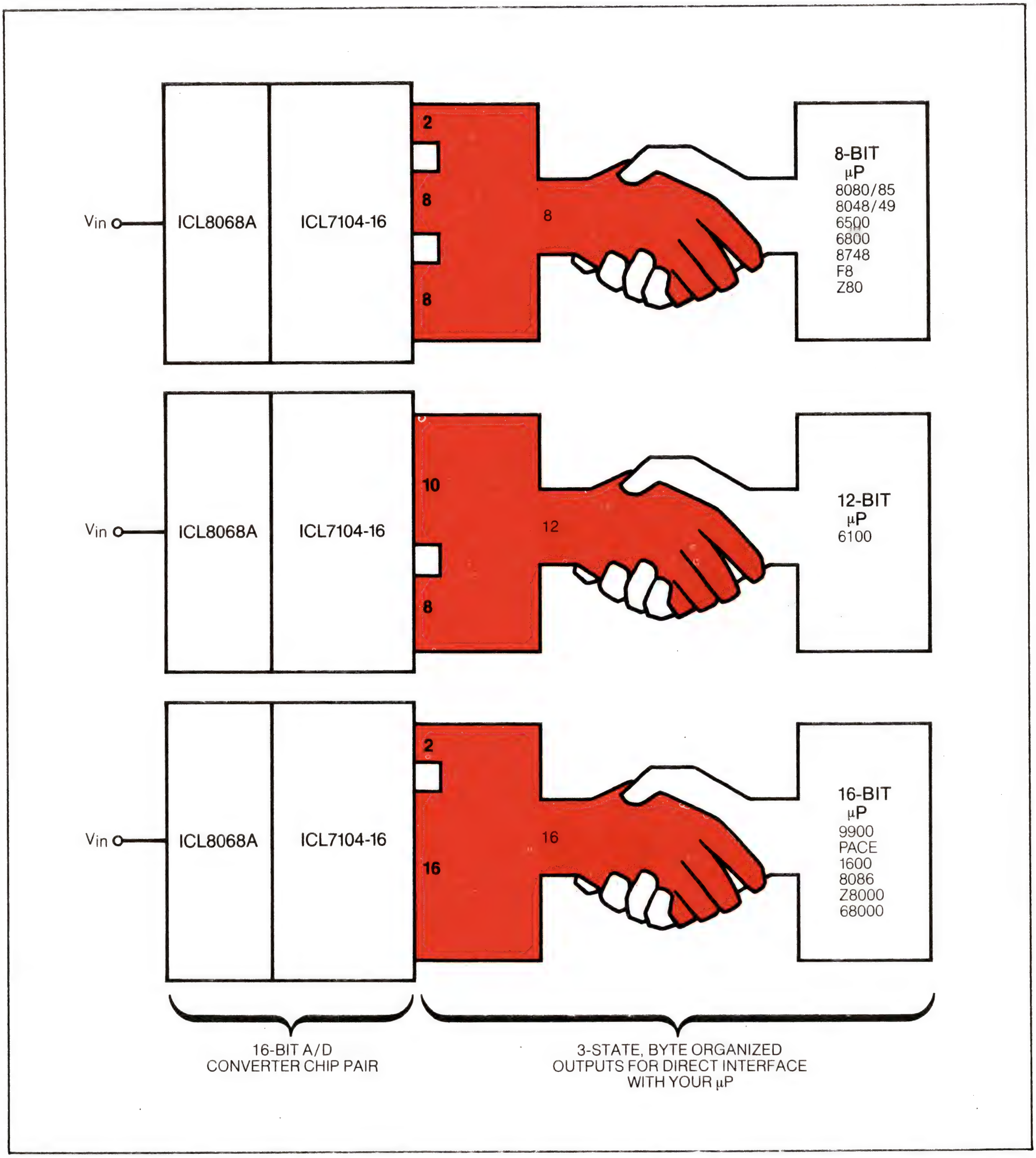

Editorial

R_x for design headaches: a written guarantee

Recently, the mail brought an interesting stack of correspondence from a reader whose tale of woe should be fair warning to all. The man is an electronic-design engineer with more than 20 years of experience, eight in computers.

Two years ago, he began building a computer system for use in his consulting business. He originally planned to buy all system components from one manufacturer, but after building his CRT terminal, he was attracted by an ad in an electronics magazine to a microcomputer from a different manufacturer. This μC was a more powerful disc-based machine that was advertised to have an "RS-232 serial interface for interfacing to *your* CRT terminal or Teletype." The company also advertised an "industry-standard S-100 bus."

Imagine, then, how this designer's enthusiasm turned to consternation when neither his CRT terminal nor his memory boards (bought from a third manufacturer) would work with the computer. Imagine further how consternation turned to disgust, when after 6 months of correspondence with the computer manufacturer, he determined that not only would he receive no assistance, but also that chances were small that *any* terminal or memory made by a firm other than the computer manufacturer itself would work with that manufacturer's product. This, despite the advertised claim and the verbal assurances provided at the time of purchase that he'd have no problems.

The real irony here is the Catch 22 implication: The ad said any CRT terminal would work; when the designer's didn't, the computer manufacturer modified its position, saying that it couldn't assure that any terminal other than its own would function. Yet at the time of purchase, the manufacturer didn't even offer a terminal for sale.

This saga confirms a recent *Business Week* article, which stated that "80% of the computer-kit assemblies undertaken end in failure." It should forewarn you: Don't rely on advertising claims or verbal assurances that system components from different manufacturers will play together properly. (EDN learned this lesson during our Project Indecomp last year.) Rather, try to get your assurances in writing from the manufacturer (good luck!) and determine what kind of technical assistance you'll receive if purchased equipment doesn't interface as claimed.

Roy W. Forsberg

Roy Forsberg
Editorial Director

An Award*-Winning Magazine
1978 Staff-Written Series — System Design Project
1978 Contributed Series — Designer's Guide to Fiber Optics
1977 Contributed Series — Software Design Course
1976 Special Issue — Microprocessor Reference Issue
1975 Staff-Written Series — Microprocessor Design Series

**Jesse H Neal Editorial Achievement Awards are the business-press Pulitzer Prize equivalent.*

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Leadtime Index

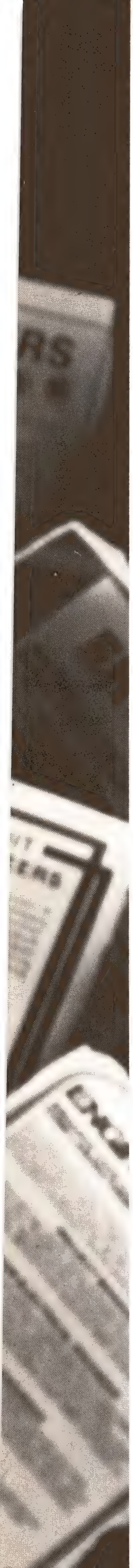
PASSIVE COMPONENTS

PRODUCT	LEADTIME IN WEEKS Min.	Max.	Trend
CAPACITORS			
Ceramic, disc	8	14	up
Ceramic, monolithic	8	15	=
Electrolytic, aluminum	8	14	=
Electrolytic, tantalum	10	24	up
Film	6	10	=
Mica	18	35	up
Paper	8	14	=
Trimming	8	12	up
CRYSTALS, FILTERS AND NETWORKS			
Filter, active	9	19	up
Filter, EMI	14	18	up
Filter, lumped-constant	12	15	up
Filter, quartz (monolithic)	11	17	up
Freq. determining crystal	7	12	=
ENCLOSURES			
Custom	8	10	=
Modified standard	10	14	=
Standard	8	10	up
FANS AND BLOWERS	4	6	up
FRACTIONAL HP MOTORS	14	16	=
INDUCTIVE COMPONENTS			
Coil	8	10	=
Solenoid	8	10	up
Transformer, power	10	15	=
Transformer, other	10	15	=
INTERCONNECTION COMPONENTS			
Back panel	12	19	=
Flat cable	9	20	=
Multipin circular high-density	23	29	=
Multipin circular standard	19	27	=
Packaging panel	20	28	=
PC, one-piece	8	12	=
PC, two-piece	8	14	=
Rack and panel	15	17	=
RF coaxial	17	25	=
Socket	12	26	=
PRINTED CIRCUITS			
Double-sided	10	18	up
Flexible	8	10	up
Multilayer	11	17	=

PRODUCT	LEADTIME IN WEEKS Min	Max	Trend
Single-sided	5	9	=
RELAYS AND TIMERS			
Crystal can	8	10	=
General purpose	9	11	=
Miniature (TO-5, square)	16	24	up
Reed, dry	7	11	=
Reed, mercury-wetted	9	12	=
Solid state	4	8	=
Telephone	15	19	=
Time delay and timer	12	14	=
RESISTORS, FIXED			
Carbon film	2	9	up
Composition	2	18	=
Metal film	10	16	=
Network	11	21	=
Wirewound	10	13	=
RESISTORS, VARIABLE			
Pot, nonprecision WW	10	12	=
Pot, precision WW	10	14	=
Pot, nonprecision comp.	10	14	=
Pot, precision comp.	10	16	=
Trimmer, WW	8	12	=
Trimmer, comp.	6	13	=
SWITCHES AND KEYBOARDS			
Circuit breaker	8	12	=
Dual in-line	8	12	=
Keyboard and keyswitch	6	8	=
Lighted pushbutton	8	12	=
Pushbutton	10	14	=
Rotary	10	18	up
Snap action	8	10	=
Thumbwheel	14	16	=
Toggle	8	12	=
TRANSDUCERS			
Pressure	4	16	=
Temperature	6	10	=
WIRE AND CABLE			
Coaxial cable	6	10	=
Flat and ribbon cable	3	8	=
Hookup wire	4	7	=
Multiconductor cable	11	15	=

Leadtimes are based on recent figures supplied to *Electronic Business* magazine by a composite group of major manufacturers and OEMs. They represent the typical times necessary to allocate manufacturing capacity to build and ship a medium-sized order for a moderately popular item. Trends represent changes expected for next month.

Announcing a proven solution to today's shortage of design engineers.



It is now estimated that there is a nationwide shortage of 15,000 design engineers.*

If your company isn't feeling the pinch, chances are you soon will.

Which means you and your staff will have to do more work with the same number of people.

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*Dun's Review; June, 1979

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3 The correct cartridge is located and loaded.
Time required: :20 seconds

4 Then, he reviews the catalog data sheets of all 85 possible vendors. He selects 4 that specifically meet his product requirements.
Time required: 8:00 minutes

5 He pushes the print button to obtain copies of the selected catalog data sheets.
Time required: 1:45 minutes
TOTAL ELAPSED TIME: 11:35 minutes

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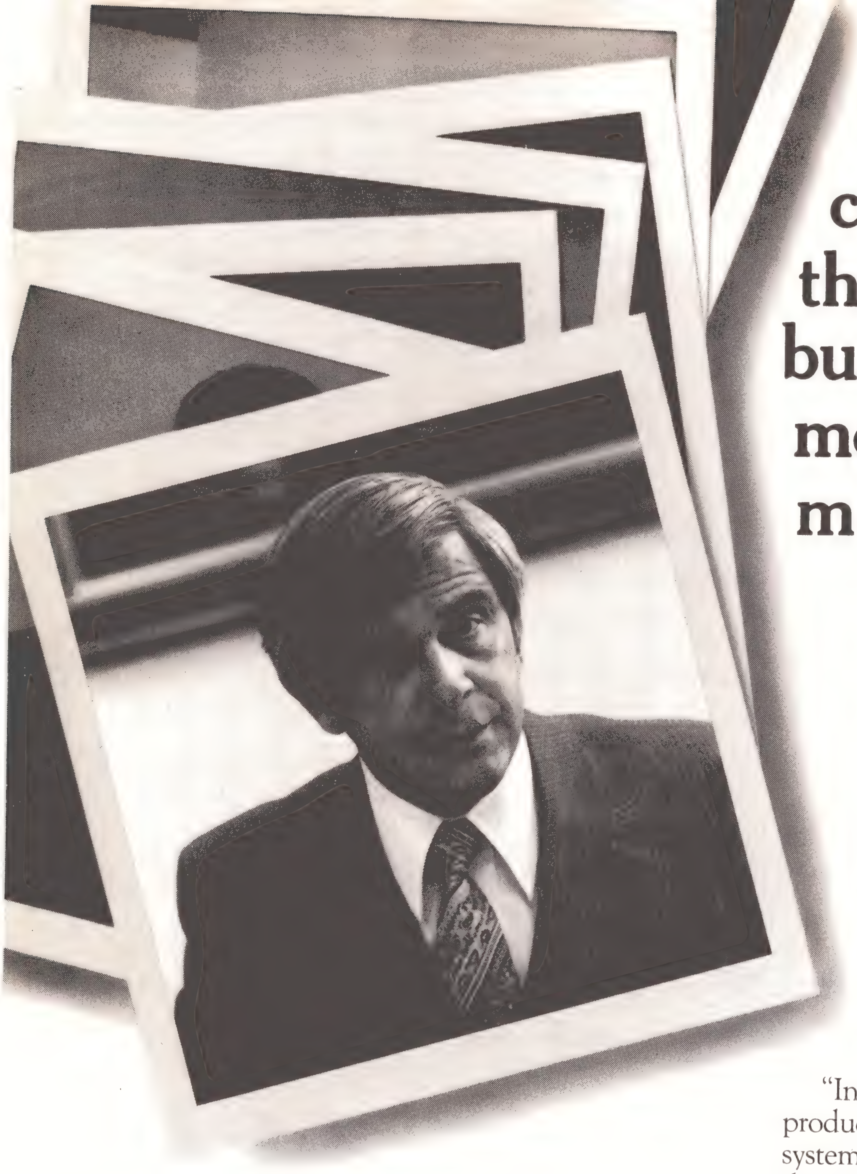

"The more competitive the video terminal business gets, the more Intel helps us maintain leadership."

Sal Nuzzo, President, Hazeltine Corporation

Sal Nuzzo: "Intel's introduction of the microcomputer revolutionized the computer terminal industry. We were first to use a microcomputer in a terminal — Intel's 8008, years ago, and we've maintained a price/performance edge over the years by quickly taking advantage of Intel's breakthroughs.

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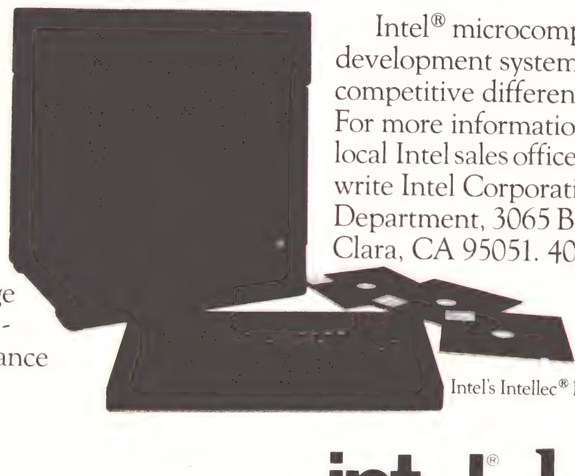

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Technology News

Probes and test cells simplify EMI testing

Andy Santoni, Western Editor

Researchers at the National Bureau of Standards, Boulder, CO, are attacking both sides of the electromagnetic-interference testing problem: They are developing new methods for measuring the interference radiated near an object and for generating the uniform fields used in testing electronic equipment's EMI susceptibility. These latest NBS initiatives in the war on EMI (see the Special Report on pg 164 of this issue for an update on action at other fronts) include:

- A new isotropic probe that permits the measurement of either plane waves or complex fields, including the near zone of complicated antenna arrays
- Continued development efforts on a rectangular coaxial line, termed a transverse electromagnetic (TEM) cell, that serves as a broadband linear phase and amplitude transducer to establish standard electromagnetic fields for susceptibility testing.

Better than standard meters

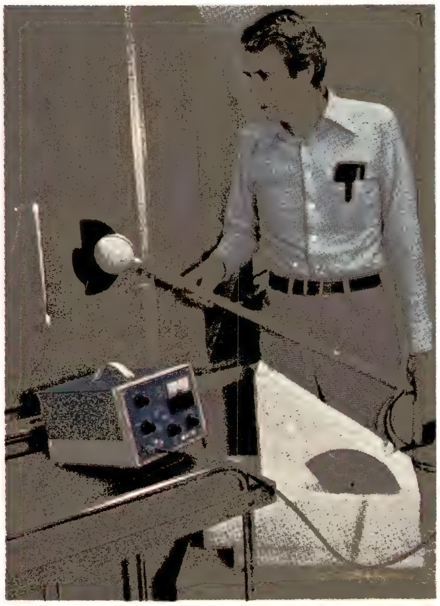
The measuring probe and the instrument it works with handle electric fields from 200 kHz to 1 GHz. According to Francis Ries, deputy chief of the EMI/Radiation Hazards Metrology Program at NBS, the probe does something most conventional field-intensity meters (which use directional antennas) cannot do: It reliably measures complex electromagnetic fields, such as those with reactive near-field components, multipath reflections, undetermined field polarization, multiple frequency components, complicated modulations and large gradients.

The probe's sensor consists of three orthogonal dipole antennas, each 5 cm long, with a diode detector connected across the center gap of each dipole. The diodes — 5802-2837 beam-lead Schottky-barrier types—can withstand a peak reverse voltage of 70V, nearly 20 dB above that produced by a continuous-wave field of 1000V/m. Thus, the sensor is virtually burnout proof in high-level cw fields.

The probe's overload or burnout-field level for pulsed signals has not yet been determined, however. The researchers are somewhat concerned about its operation in such fields—especially those with low duty cycles—because of the fields' high levels during pulse-on times.

Cables reject interference

Each detector diode in the NBS probe connects to one of the metering unit's three input channels by means of high-resistance carbon-filled Teflon wire, which is



An isotropic antenna *developed at the National Bureau of Standards, Boulder, CO, is small and sensitive enough to measure the electromagnetic fields generated near signal sources. Its metering circuitry is housed in the blue box.*

The susceptibility *of electronic equipment to electromagnetic interference can be measured with a transverse electromagnetic (TEM) cell like this 3m-cross-section unit. The cell's input connector is at the tip of the pyramid-shaped section on the left.*

virtually insensitive to electromagnetic fields. The resistance of each plastic filament is about 80 kΩ/cm for the 15 cm nearest the detector and about 700Ω/cm for the remainder of the line.

The leads don't perturb the field under test, either, because their high resistance results in low current flow. Their sandwich construction also results in a large shunt capacitance, which increases RF filtering and permits only dc-signal conduction to the meter.

The researchers reduce the electrometer effect caused by dc and low-frequency fields by means of a slightly conducting heat-shrinkable tubing that surrounds the probe's 6-conductor resistance line and connects to the metering unit's circuit ground. "Flexural" noise—manifested as fluctuations in meter indication whenever the resistance line is bent or flexed and apparently caused by electrostatic and capacitive currents between the line's carbon granules—is reduced by keeping the line stationary during measurements.

The detected signals from the probe are shaped to obtain a dc voltage proportional to the sum of the squares of the three orthogonal electric-field components. An analog module then delivers a dc voltage that's read out on the meter in units of dB above 1V/m, 10V/m or 100V/m, depending on the range selected.

The measurement probe's small size—even equipped with a protective Styrofoam globe, it's only 10 cm in diameter—makes it flexible and allows it to measure fields very close to EMI-producing equipment. It's small enough to move around and thus allows a user to roughly determine a field's polarization; if the X- and Y-axis fields are equal, for example, the measured wave is likely to be circularly polarized. Larger antennas have better sensitivity, says Ries, but they can't be reoriented to make measurements on different axes in this manner.

Larger antennas also can't get conveniently close to electromagnetic sources—into the regions most likely to exhibit large amounts of EMI. Then, too, only small probes can resolve small spatial variations in field intensity.

To date, NBS has built three measurement units and several antennas utilizing the probe for use by various government agencies. The agency can't build units for commercial sales, explains Ries, but it will provide circuit details to interested manufacturers.

Eliminating the antenna

All antennas, no matter how well designed and manufactured, suffer from limitations in bandwidth, directivity and phase linearity. The second NBS device, the TEM cell, is designed to overcome these limitations in EMI measurements as well as in generating electromagnetic fields.

The cell's cross section resembles a rectangular-cross-section segment of coaxial 50Ω transmission line, tapered at each end to adapt to conventional 50Ω coaxial connectors. Its center conductor is a flat metal sheet, supported by dielectric rods in the center of the cell.

The cell either converts an electric field set up within its boundaries into an RF voltage or converts such a voltage fed into its input terminals into an electromagnetic field. Thus, it can either detect radiated emanations from electronic equipment or establish standard electromagnetic fields for susceptibility testing of such equipment.

In the generating mode, the cell propagates a TEM wave characterized by orthogonal electric and magnetic fields. These fields are perpendicular to the direction of propagation along the length of the cell and are uniform over much of the space between the cell's center conducting sheet (septum) and outer conducting shell.

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Isolation (dB)		Typ.	Max.
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	LO-IF	45	35
5-250 MHz	LO-RF	45	30
	LO-IF	40	25
250-500 MHz	LO-RF	35	25
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this mode, according to John Workman, a technician in the NBS EMI/Radiation Hazards Metrology Program. However, the cell's magnetic shielding becomes less effective as frequency decreases.

The cell's upper useful frequency is limited by distortion of the test signal caused by resonances and multimoding, explains Workman. These effects are minimized by installation of RF-absorbing material inside the cell—a procedure that raises the upper useful frequency to 47 MHz in the largest configuration NBS has built to date: 3×3m in cross section and 6m long.

Measuring susceptibility

Although either the cell's top or bottom half can be used for susceptibility measurements, researchers generally use the latter so that the equipment under test can be supported by the bottom of the cell instead of the center conductor. The equipment is placed so that its center lies midway between the septum and the bottom of the cell and midway between the two side walls—the region in which the TEM field is most uniform.

For best results, says Workman, the equipment under test should measure less than one-third the distance between the septum and the bottom and less than one-third the distance between the sides of the cell's main body; larger configurations cause excessive capacitive loading and short out part of the vertical test field, distorting the test-field pattern. For smaller objects, the cell's transmission-line impedance changes by less than 2Ω, and the test field increases by less than 3 to 6 dB.

Of course, a complete test plan includes a selection of measurement frequencies, waveform levels and other characteristics, exposure angles and the number of I/O leads connected to the unit under test; writing such a plan is a complex task that depends greatly on the nature of the equipment under test. **EDN**

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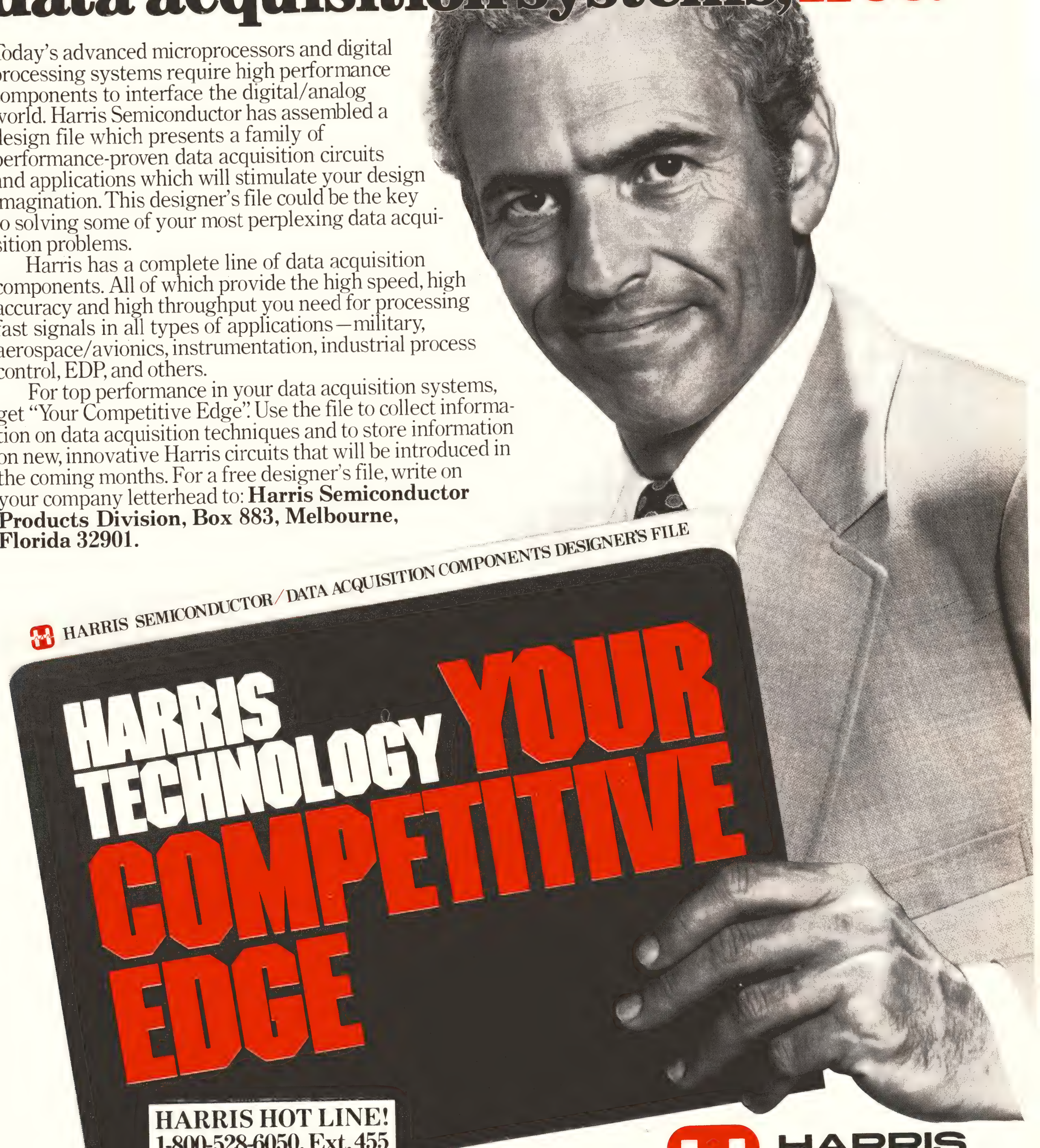

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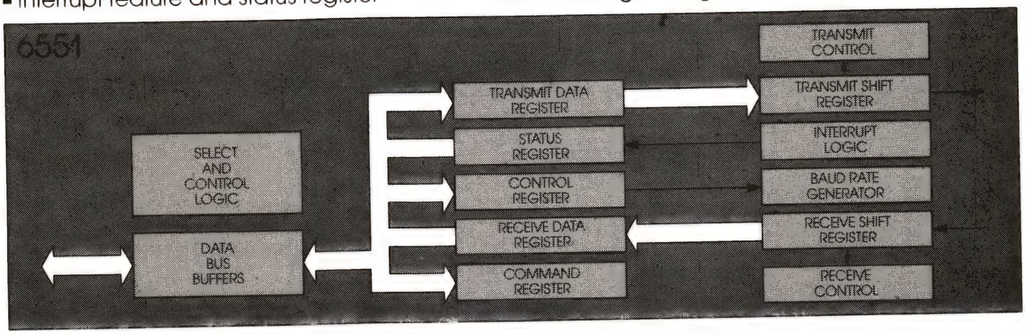

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Catastrophic failures limit applications of high-density epoxy/glass pc boards

Dale Zeskind, Contributing Editor

If you contemplate using conventional epoxy/glass pc boards in high-density applications (conductor spacings in the 10-mil range), and if those boards will routinely experience relative humidities of 80% or more—beware. Researchers have recently identified an intrinsic failure mechanism in such pc boards which could limit their use.

The discovery comes at a time when the trend toward VLSI circuitry has greatly increased

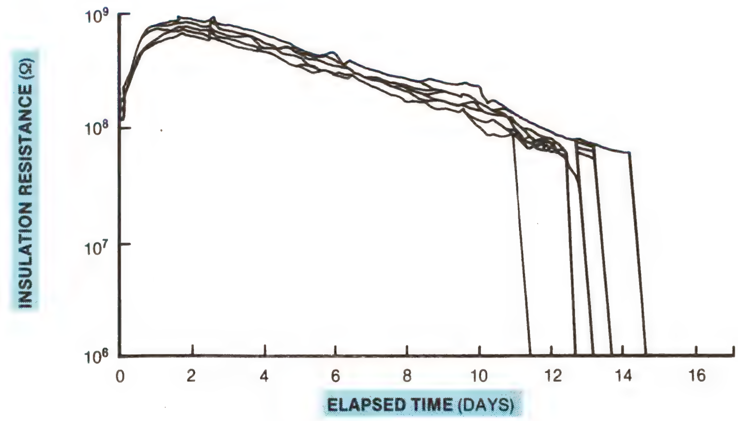

Fig 1—A catastrophic loss of insulation resistance *between closely spaced conductors maintained at different potentials characterizes a recently described pc-board failure mechanism.*

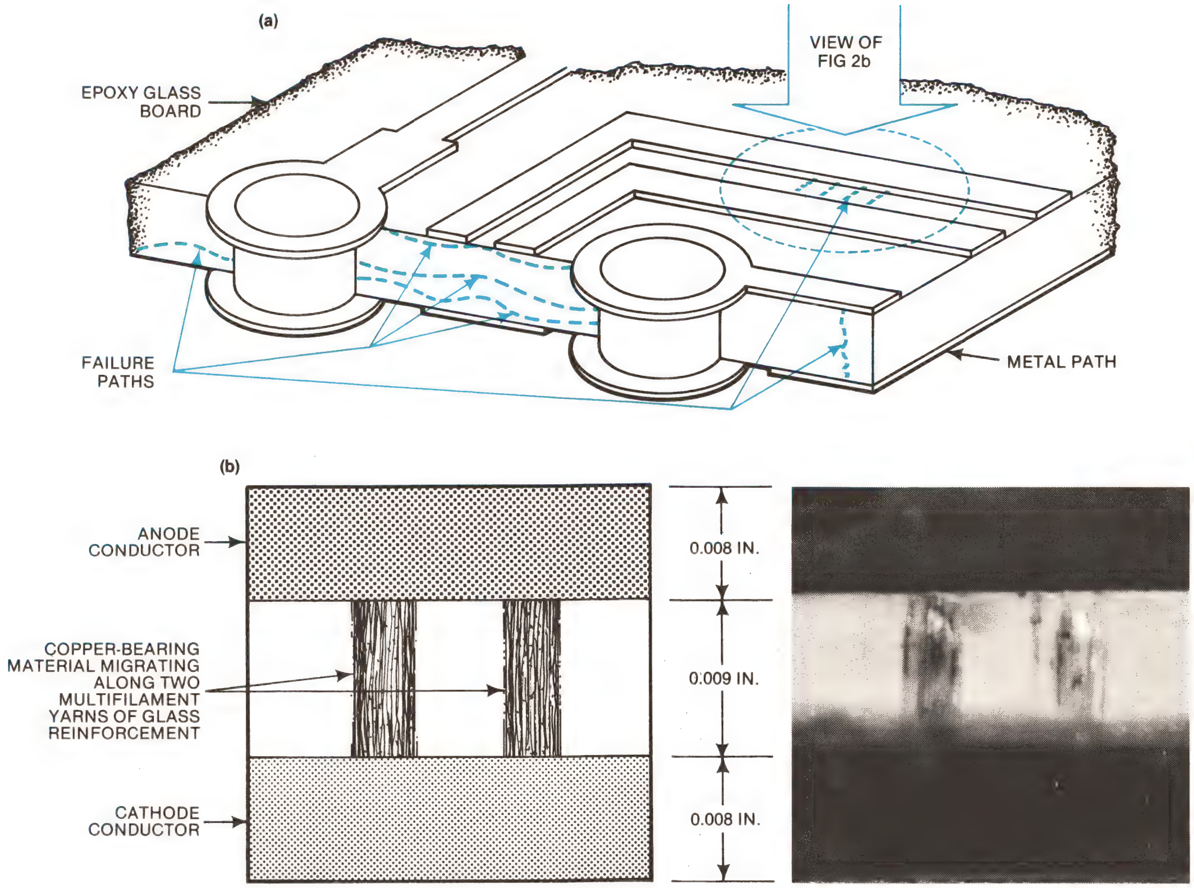

Fig 2—Loss in insulation resistance *results from the electrochemical growth of a conductive copper compound along a board's internal glass filaments* ***(a)****; the photograph in* ***(b)*** *shows two actual failure paths between conductors fabricated on a 5-mil-thick FR-4 epoxy/glass substrate. These failure paths arose after 100 days at 50°C, 80% relative humidity and 80V bias.*

pc-board density and has made circuit applications in remote hostile environments more common than ever. Indeed, it suggests that current high-density board designs with 5- to 10-mil conductor spacings press the limits of today's epoxy/glass materials.

Lose insulation resistance

The failure mechanism is characterized by a catastrophic loss of insulation resistance between closely spaced conductors maintained at different potentials.

Fig 1 shows typical pc-board insulation-resistance behavior under conditions of accelerated aging—data presented at the recent IEEE International Reliability Physics Symposium by Drs J N Lahti and D J Lando of Bell Labs, Whippany, NJ. As shown, the resistance between biased conductors gradually declines and then suffers an abrupt catastrophic-drop signaling failure.

Lahti and Lando explain that this severe loss in insulation resistance results from the electrochemical growth of a conductive copper compound along a board's internal glass filaments. The growth begins at the anode conductor and penetrates the dielectric along the epoxy/glass interface.

The gradual decline in insulation resistance before failure usually results from degradation in the board's surface coating. Uncoated boards, on the other hand, experience little degradation in insulation resistance prior to failure, say the researchers.

Watch it happen

Fig 2a illustrates some possible failure paths; you can actually observe the failure mechanism at work in **Fig 2b**.

According to Lahti and Lando, an "articulation" or visual enhancement of the glass reinforcement around the anode heralds the beginning of the failure. This optical effect results from a physical

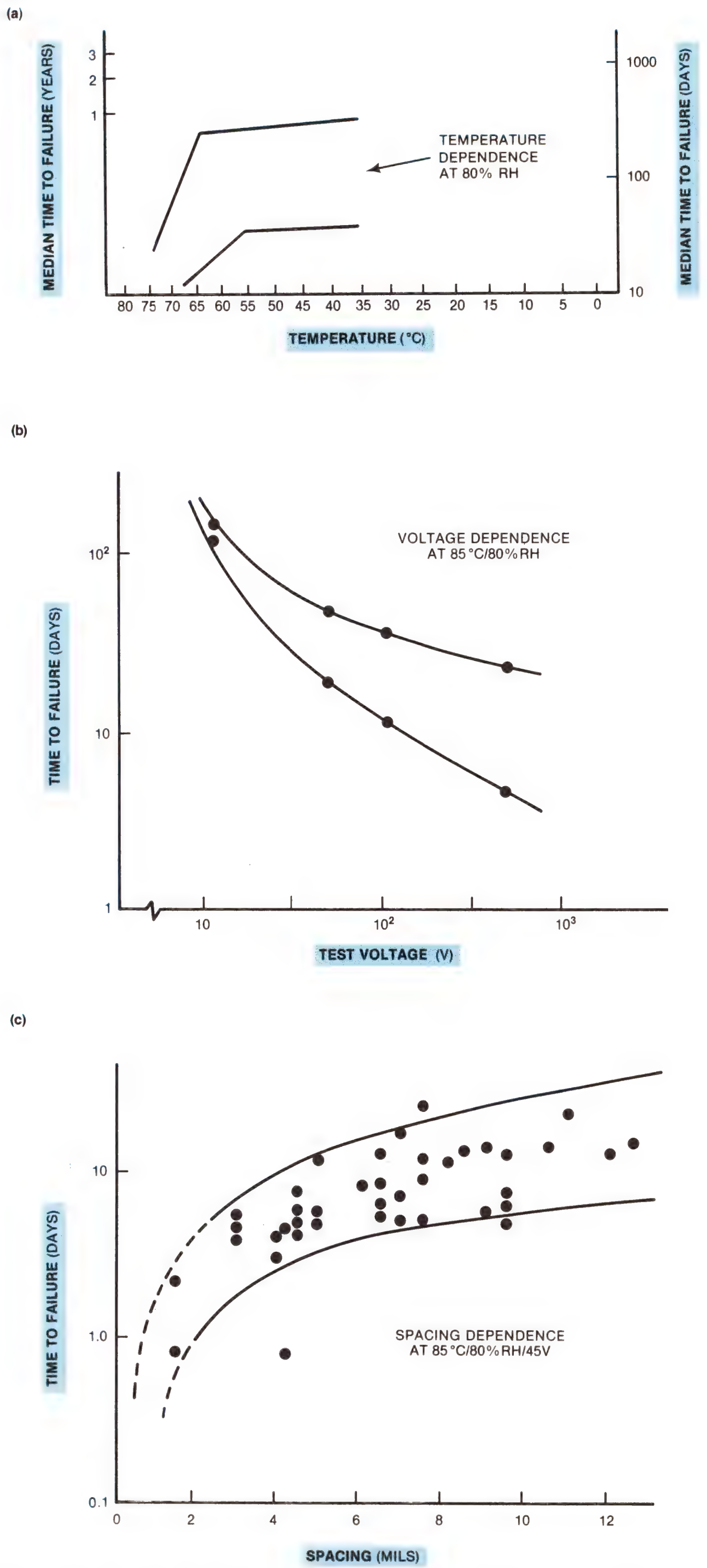

Fig 3—Time to failure *decreases with increasing temperature, as indicated by the shaded band of data* ***(a)****. It also decreases with increasing voltage* ***(b)*** *and drops drastically as conductor spacings decrease below 5 mils* ***(c)****.*

separation at the epoxy/glass interface.

Dark copper-bearing material fills the articulated regions and grows away from the anodes toward the cathodically biased conductors. When the growth spans the region between conductors, a short circuit develops, producing the drop in insulation resistance.

The risk of failure increases drastically with increasing relative humidity, although temperature increases also raise it **(Fig 3a). Fig 3b** illustrates the effect of voltage, and **Fig 3c** depicts the influence of conductor spacing on failure time.

Examine board construction

A typical epoxy/glass circuit board consists of a homogeneous mixture of epoxy resin with interlaced glass-fiber reinforcement. The close proximity of the glass to the board's copper cladding aggravates the failure mechanism.

One obvious preventive measure, therefore, is to include a layer of pure epoxy resin between the copper cladding and the board's central glass-reinforced portion. But although this approach might reduce the failure between surface conductors, Lahti and Lando point out that it won't prevent failure between plated-through holes.

Board-processing factors such as chemistry, lamination parameters, baking, fluxing, soldering and cleaning also influence board life, although the researchers note that the nature of these influences is not yet clearly understood.

However, they stress that foreign-fiber contamination of the board material clearly does degrade board reliability: The failure mechanism proceeds much more rapidly along foreign fibers than glass ones. Preventing contamination during board construction therefore becomes critical.

Lahti and Lando have also observed that protective coatings applied to a finished printed circuit often intensify the epoxy/glass failure. Additionally, failures in multilayer boards tend to occur first on the innermost layers, and later on the layers closest to the surface.

Alternatives considered

Although adding resin-rich layers between the copper cladding and glass reinforcement can reduce the occurrence of the failure mechanism, Lahti and Lando speculate that the real solution might require eliminating epoxy/glass entirely as a pc-board material. They have obtained good results with triazine/glass boards, and investigators are also considering using several solid thermoplastic and thermoset resins as substrate materials. **EDN**

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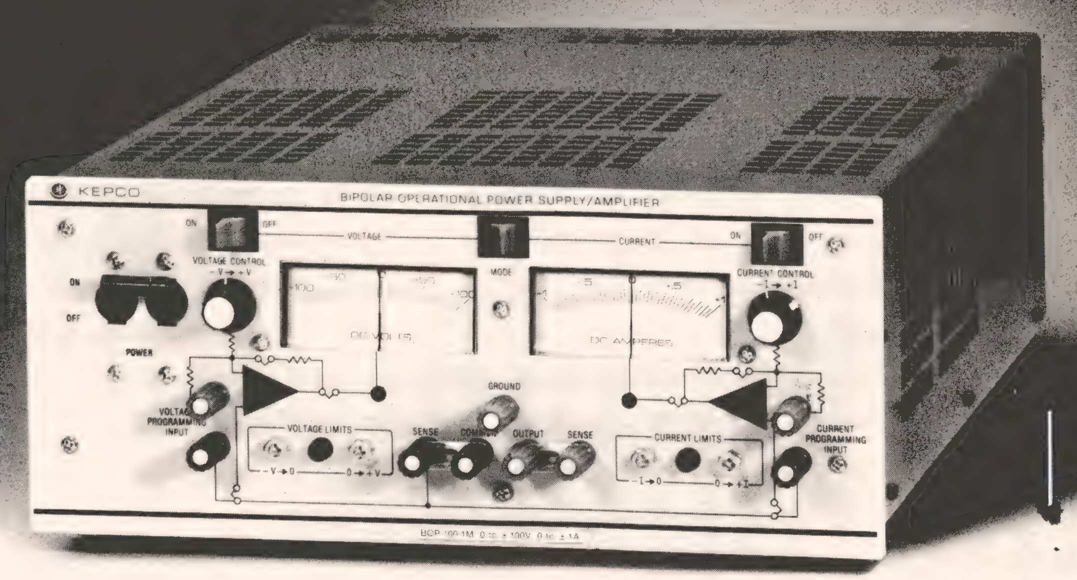

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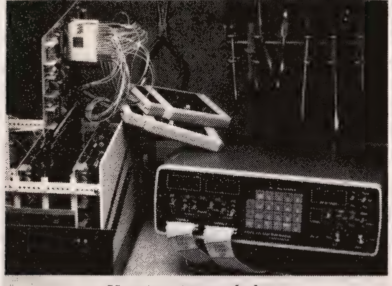
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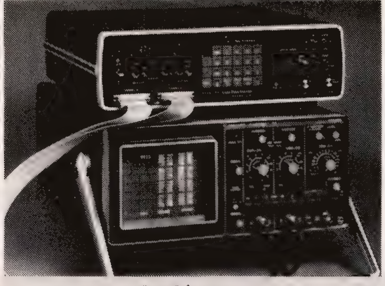
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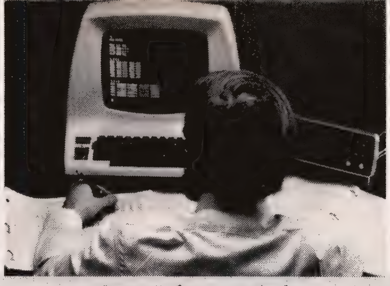
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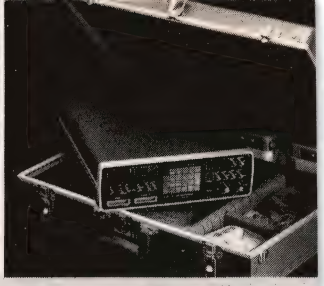
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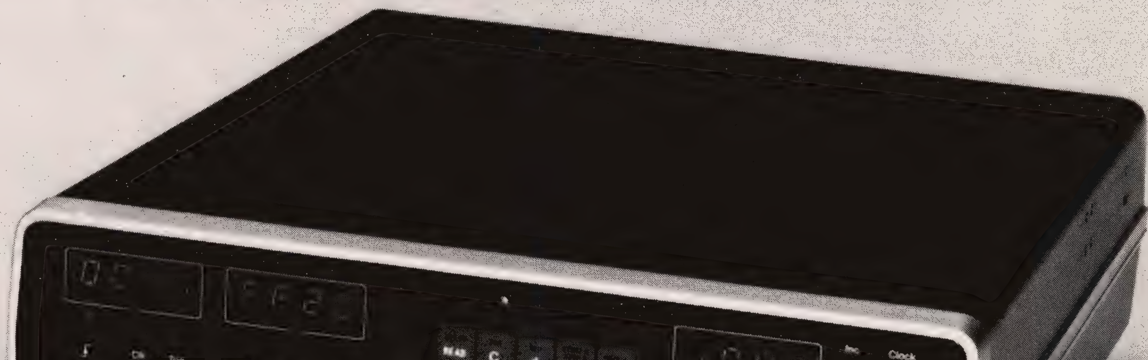

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Circular connectors employ novel designs to deal with tough commercial environments

Tom Ormond, Senior Editor

Circular connectors—until now primarily used in military/aerospace applications—are increasingly finding use in nonmilitary systems.

The commercial devices used in such systems, though, are not merely second-rate versions of high-reliability military designs. Indeed, in at least two application areas—in the trucking industry and in a CB-radio system—the commercial models actually satisfy user requirements better than MIL-spec'd devices. In both cases, the impetus behind circular connectors' penetration of the commercial marketplace is the need for a highly reliable connector that can perform economically under a variety of environmental conditions.

Keep the big wheels rolling

In the pre-electronic era, the devices used for electrical interconnection in heavy-duty transportation equipment were crude but adequate **(Fig 1)**. Connections were typically wired one line at a time, with the wires attached by means of set screws. And although these connections were open to the environment, the heavy currents carried burned off contaminants and corrosion to maintain circuit functions.

Today, however, the trucking industry's increased use of electronics has complicated the picture. Greater numbers of interconnects are involved, so connector assembly time becomes a crucial factor. In addition, signal levels are no longer high enough to burn off contaminants, so the interconnects must be protected from the environment to prevent contact degradation. Fortunately, various circular-connector manufacturers have developed products that provide economical and reliable solutions to these problems.

Available in a range of sizes and contact layouts, ITT Cannon's VE Series connectors **(Fig 2a)** consist of three basic elements—metal shell, single-piece monoblock insulator and crimp contact. Environmental protection—against steam, water, gasoline, diesel fuel, brake fluid, transmission fluid, ethylene glycol and oil—comes from a gasket which seals the shell and barrel when mated and an individual wire-sealing grommet.

Internal diaphragms in the grommet's wire cavities prevent the entry of contamination and mois-

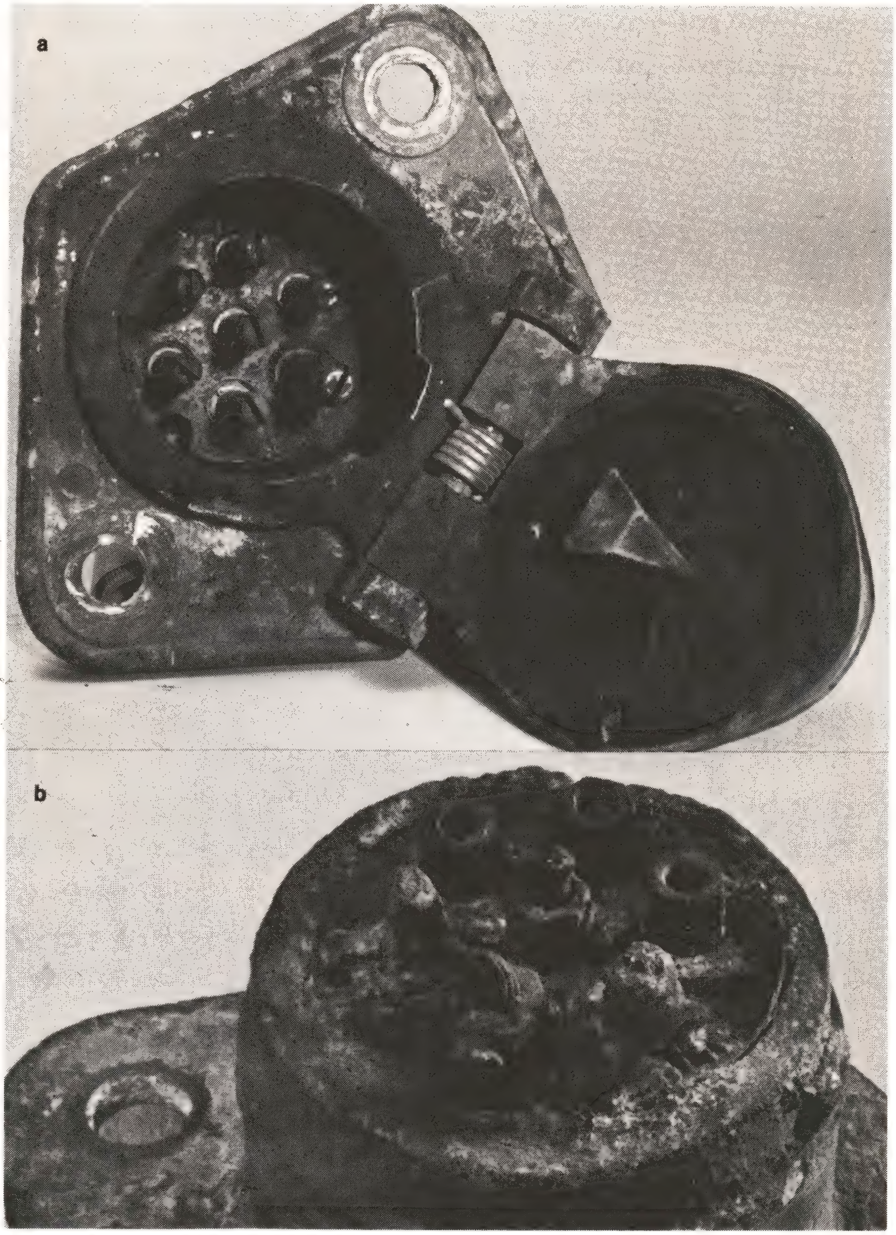

Fig 1—It's a tough and dirty world *for connectors used in the heavy-duty-transportation industry. In the pre-electronic era, such connectors were open to the environment* ***(a)*** *and relied on heavy signal currents to burn off contaminants. It's easy to see, therefore* ***(b)****, why 60% of truck-maintenance dollars were spent on solving electrical problems.*

ture. (The diaphragms are easily punctured when contacts are inserted.) The stamped and formed contacts are plated with a high-performance alloy to maintain low contact resistance throughout connector lifetime.

Among the key performance-characteristic tests passed by VE Series devices are: thermal shock—five cycles of −40 to +105°C temperature change; durability—240 mating/unmating cycles; temperature life—500 hrs at 105°C; and mechanical shock—50g, half sine, 3-axis.

Also available in a variety of sizes and contact layouts for use in trucking applications, Deutsch HD Series cylindrical connectors **(Fig 2b)** use crimp-type solid copper-alloy contacts that are easily installed in the field. Like the Cannon units, these devices are completely sealed.

At the rear of each connector, an integral grommet wire seal automatically seals each contact as it is locked into place during installation. For additional protection, a silicone-rubber blanket is located on the connector's face to keep out moisture and other contaminants.

The Deutsch connectors operate over a −55 to +125°C range and are guaranteed to exhibit no electrical or mechanical defects after 100 mating/unmating cycles. They feature a lightweight, rugged metal shell to protect contacts and sealing grommets; the shell provides a multiple keying system that positively prevents mismating and makes plug and receptacle coupling quick and easy. In addition, the connectors use a quick-disconnect bayonet coupling system that provides a positive vibration-resistant locking mechanism.

In its Econoseal line **(Fig 2c)**, AMP has taken a different design approach than Cannon and Deutsch. These devices feature factory-installed elastomeric wire seals and a peripheral mating-face seal. However, once contacts are inserted through a wire seal, they cannot be extracted; should contact replacement be required, the seal must also be replaced.

Econoseal devices come in 3-, 4-, 7- and 9-position sizes. Their polarized and keyed housings latch together and can be panel-mounted with a simple snap ring. The connectors accept five types of contacts to accommodate solid or stranded wire, miniature coaxial cable or optical-fiber cables.

Tough problem, tough solution

Members of another circular-connector family—Burndy Corp's Bantamate II Series **(Fig 3)**—are satisfying the tough requirements

Fig 2—Reduced maintenance and improved performance *are provided by the circular connectors now employed in the trucking industry. ITT Cannon's VE Series* **(a)**, *Deutsch's HD Series* **(b)** *and AMP's Econoseal devices* **(c)** *offer total environmental sealing and provide the protection necessary to handle the low-level signals found in the electronic systems of today's trucks.*

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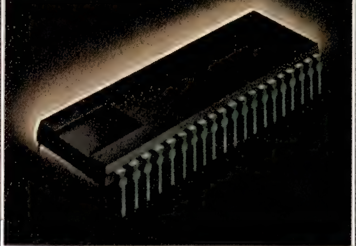

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Technology News

Ford Motor Co has set for a microphone connector to be used in a CB-radio system. Such a connector must meet automotive environmental requirements (with respect to temperature extremes, humidity, vibration and dust exposure), be simple enough for handling by nontechnical personnel and be able to provide a minimum of 5000 mating/unmating cycles.

The Bantamate II connectors employ pin-type contacts in their receptacle halves and socket-type contacts in their plug halves. A latch on the plug and a hook on the receptacle provide a quick-connect/disconnect system that securely locks the connector halves together. Despite the connectors' high-reliability design, mating and unmating are readily accomplished—even by children.

The connectors meet durability

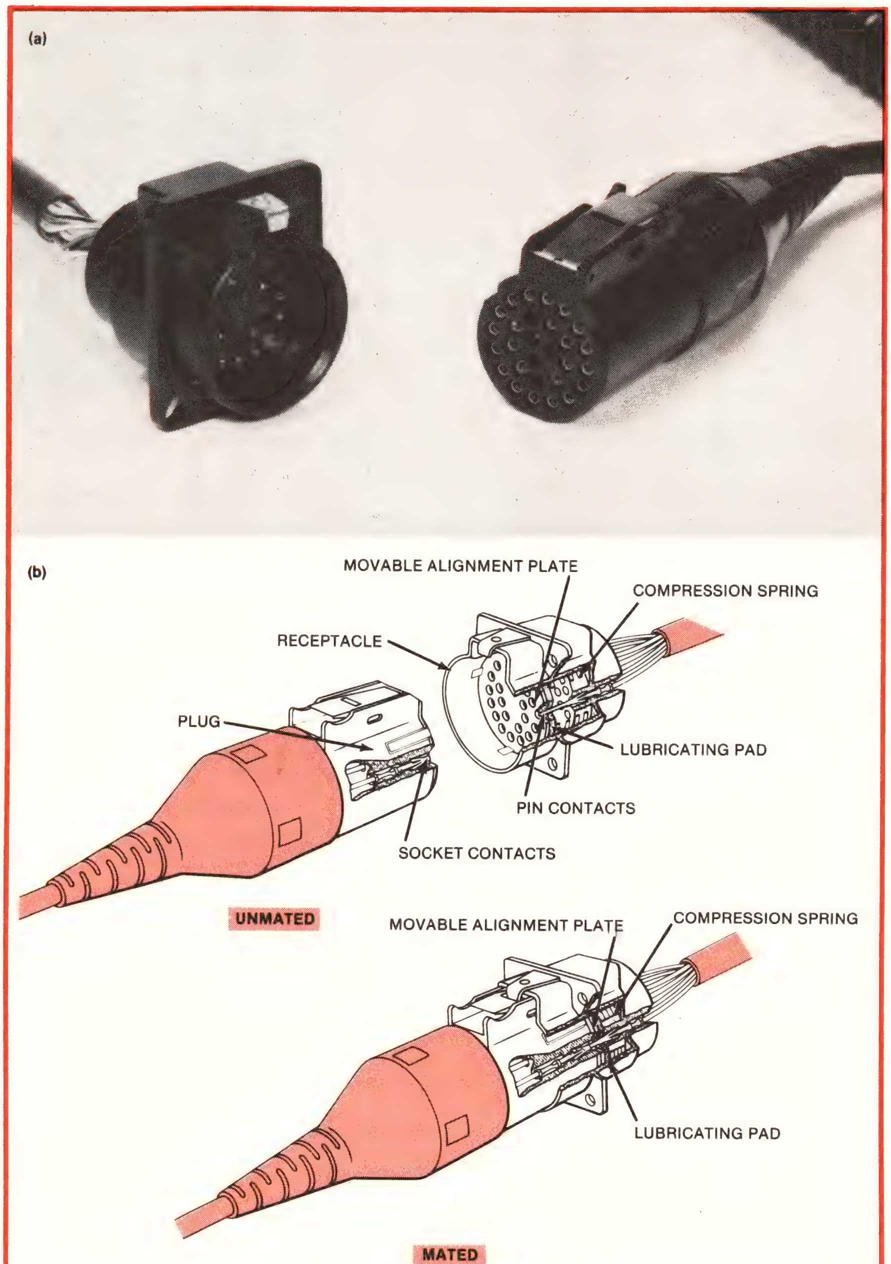

Fig 3—Extended lifetime *is the major benefit offered by Burndy's Bantamate II Series of circular connectors* ***(a)****. Used in a CB-radio application, they utilize a permanent lubrication system to achieve a lifetime in excess of 5000 mating/unmating cycles* ***(b)****.*

requirements by using a permanent lubrication system consisting of a lubricant-saturated foam pad bonded to a stripper plate and retained in the connector receptacle by three finger-type flexing members.

When the connector is unmated, a compression spring maintains the stripper plate in its normal position just above the tips of the contact pins (preventing any shock hazards). Once the plug is mated to the receptacle, the stripper-plate/pad assembly is pushed forward until it bottoms out on the receptacle's internal face, thereby squeezing some lubricant from the pad onto the plug's pin contacts. The compression spring then pushes the connector plug backward until the latching mechanism's slot engages the receptacle hook, thus releasing pressure on the pad and stopping the flow of lubricant.

Unmating the connector involves pressing the locking mechanism down and pulling on the plug; the receptacle's compression spring then returns the stripper plate to its original position. During each back-and-forth motion of the stripper-plate/pad assembly, the pins are wiped with lubricant along their surfaces, thereby minimizing wear and reducing mating forces. The result: a connector with a lifetime in excess of 5000 cycles—a tenfold improvement over typical MIL requirements. **EDN**

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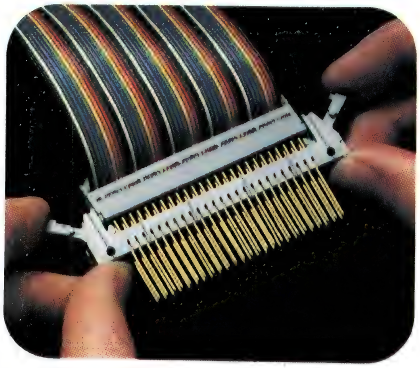
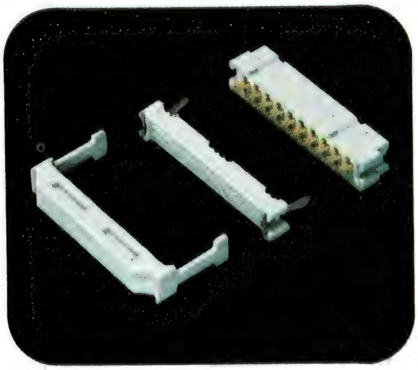


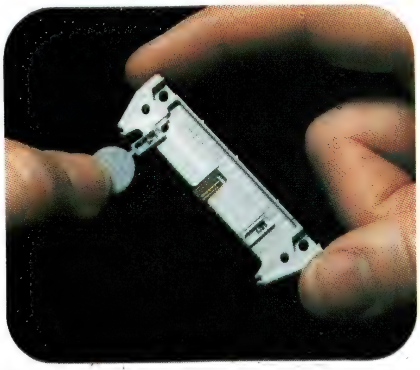
Now from 3M come several important design changes in Scotchflex brand socket connectors and headers. Changes aimed at bringing you faster assembly, increased reliability and reduced maintenance.

Scotchflex headers (.100″ x .100″ grid series) now include built-in retainer/ejector latches that snap up to lock sockets firmly in place and snap down to disconnect them quickly and easily. Latches hold tightly against vibration and shock, and their ejector feature also helps reduce wear and damage from disconnection and reconnection. They work with or without strain relief clips on both new and previous .100″ x .100″ Scotchflex socket designs.

and a snap to unplug.

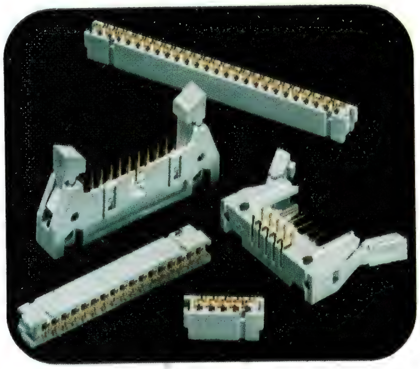


Mating socket connectors have been redesigned with metal spring clips that lock cover to body tightly, providing greatly increased cover retention. And a new one-piece strain relief clip now reduces parts inventory and cuts assembly labor time.



An improved keying system permits positive polarization without pin loss, helps reduce equipment damage and field maintenance. Connectors snap into polarized headers to insure positive mating and provide increased retention.

New socket and header sizes have been added, too. Scotchflex sockets and headers with .100″ x .100″ grid spacing are now available in 10, 14, 16, 20, 26, 34, 40, 50 and 60-pin sizes to suit your design needs.



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Flat-cable interconnection techniques bring relief to prototype-system designers

Sam Davis, Manager,
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Increasingly attracting the attention of prototype-system designers, mass-terminated flat cable satisfies the need for minimum cable-harness fabrication time, minimum cost and drudgery and maximum wiring accuracy. Although flat cable is not new—it's been used for more than a decade in production systems—only recently have prototype designers begun using this interconnection technique.

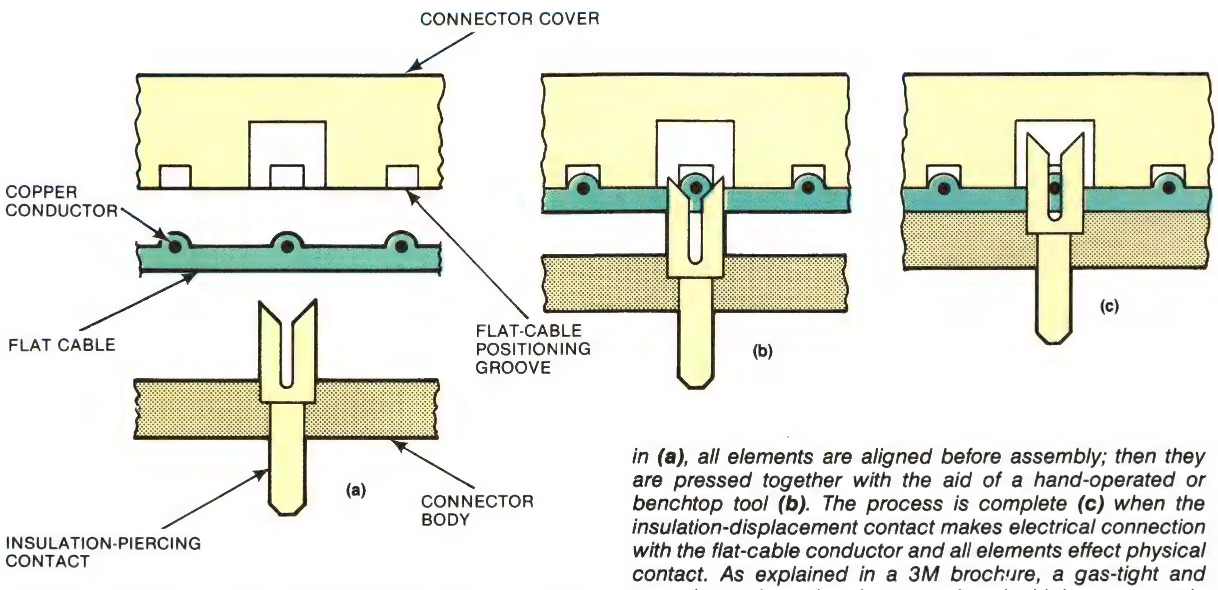
Their needs span a variety of applications; 3M marketing manager Kermit Ferrell cites an increase in inquiries from both large and small companies considering prototype/breadboard applications for flat cable. One inquiry to the St Paul, MN firm asked how mass-terminated flat cable could be applied to a tester under development: The designer wanted to connect a test panel to logic boards while retaining the ability to change connector types without causing major design glitches. As a prototype, the application called for a minimum amount of documentation; 3M suggested using flat cable and various mass-termination insulation - displacement - contact (IDC) connectors.

Making contact

What's the nature of this interconnection technique, which prototype designers are considering in ever-increasing numbers? Mass-termination flat cable, explains William Miller, president of T&B/Ansley, Los Angeles, consists of two or more electrical conductors placed side by side and embedded within a flat plastic insulator. Most varieties have center-to-center spacing of 0.05 in., with tolerances of 0.002 or 0.003 in. to ensure reliable contact with IDC connectors. Wires are solid or stranded and are usually tinned; the solid wire can be flat or round. Routing this type of cable is relatively easy, because the cable is pliable when bent along its width.

3M's Ferrell explains that flat cable offers designers predictable and repeatable electrical characteristics — characteristics that discrete wiring doesn't necessarily provide. "There are enough things for the designer to do in getting his system operational without having to worry about the unknowns of discrete wiring," Ferrell says. "Flat cable provides peace of mind when it comes to cable harnessing."

Spectra-Strip's Bennett Brachman adds that flat cable forces designers to lay out their systems in an orderly and disciplined manner. "This results in easier-to-troubleshoot systems through the elimination of the 'rat's nest' appearance of discrete wiring," explains Brachman, marketing VP at the Garden Grove, CA firm.



Mass termination of flat cable *requires alignment between the connector body and cover, the insulation-displacement contacts and the flat cable itself. In the cross-section shown in* ***(a)****, all elements are aligned before assembly; then they are pressed together with the aid of a hand-operated or benchtop tool* ***(b)****. The process is complete* ***(c)*** *when the insulation-displacement contact makes electrical connection with the flat-cable conductor and all elements effect physical contact. As explained in a 3M brochure, a gas-tight and corrosion-resistant bond occurs when the high-pressure grip caused by the deflection accompanying insertion produces a compressive force that removes any oxides or contaminants from both the conductor and contact.*

News

"Also, if the prototype design employs flat cable, the transition to a production system is relatively simple."

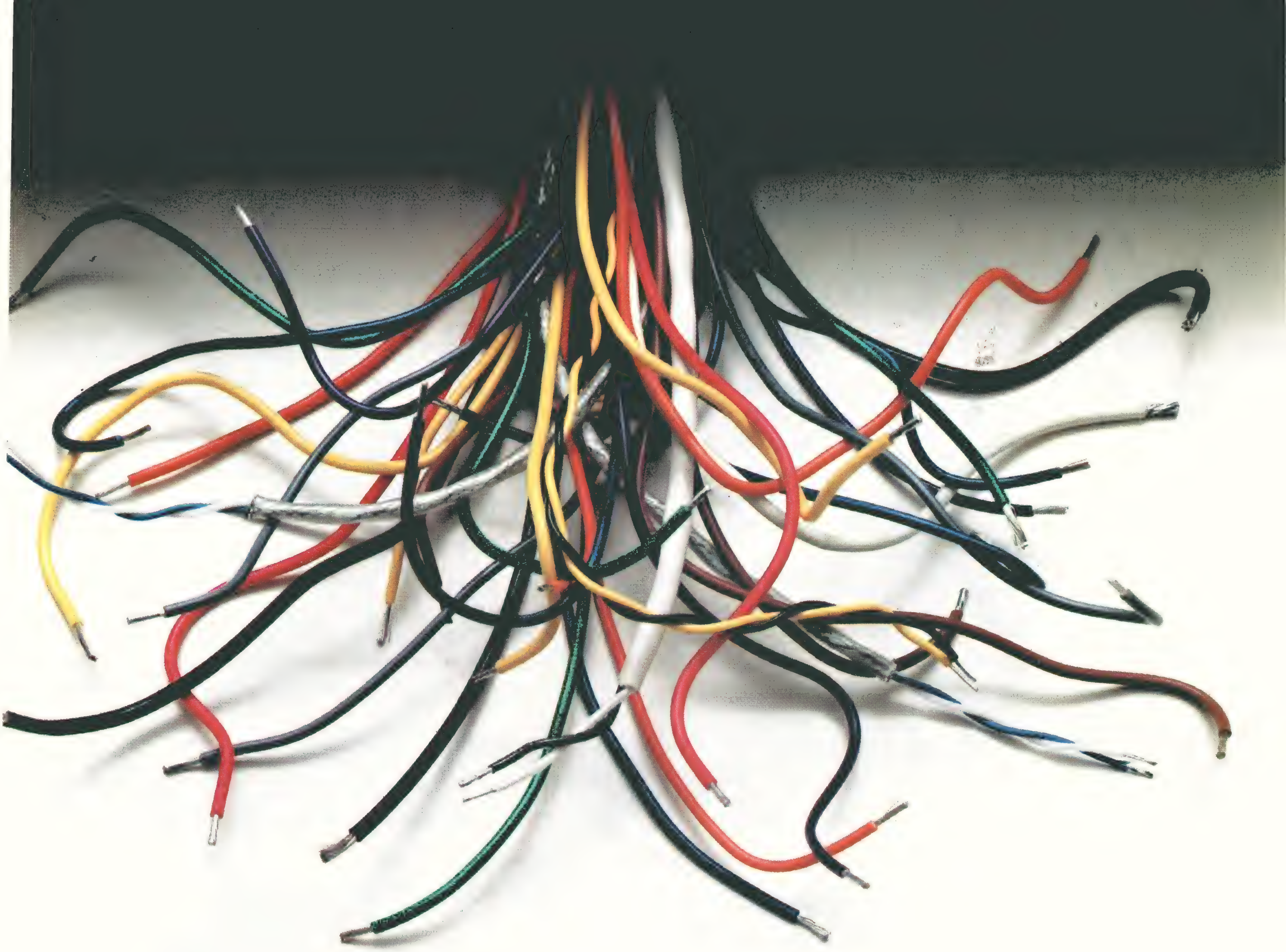
Compared with discrete-wire harnesses, flat cable exhibits an ease of daisy-chaining that makes it especially attractive for use in prototype systems. Specifically, the use of discrete-wire systems requires cutting the cable to install each connector, whereas you can install IDC connectors anywhere along the length of a flat cable without cutting it. In effect, the flat cable functions as a flexible backpanel.

Regardless of how flat cable fits into a system, though, it provides better inherent wiring accuracy than a discrete-wire harness. Discrete-wire systems require color coding or cable markers to identify each wire; wires are then bundled together and terminated individually, either by soldering or pushing crimped contacts into a connector. Even if you take the greatest care, a wiring error can still occur because of the sheer number of wires involved. On the other hand, flat cable achieves its high accuracy so long as the system's input and output lines have the proper arrangement.

Then, too, the documentation requirements of flat-cable systems are far less extensive than those of discrete-wiring approaches, where each step in the termination process requires full documentation.

Easy availability of cable, connectors and tools from local electronic-component distributors is another factor that makes flat cable attractive for prototype-system design and development. Most items are "on the shelf": You can merely go to your local distributor and pick up what you need. In addition, virtually all distributors provide value-added services, such as complete harness fabrication.

Finally, the tools for flat-cable termination require a relatively small investment; benchtop and



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For the name and number of our nearest distributor or rep, write Spectra-Strip, an Eltra Company, 7100 Lampson Avenue, Garden Grove, CA 92642. Or call (714) 892-3361 today.

When you're down to the wire

For more information, Circle No 35

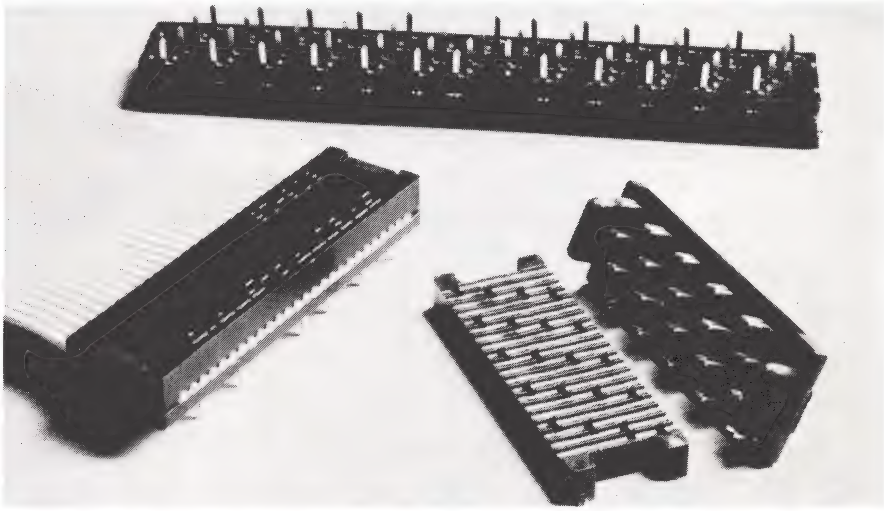
hand tools vary in price from less than $100 to about $400. The latter can serve in the lab or field, whereas some benchtop tools provide faster throughput and less fatigue through the use of compressed air. However, both types of tools have attachments that permit system fabrication with different styles of cable and connectors—although tools from one manufacturer usually don't work with cable and connectors from another one.

Labor savings

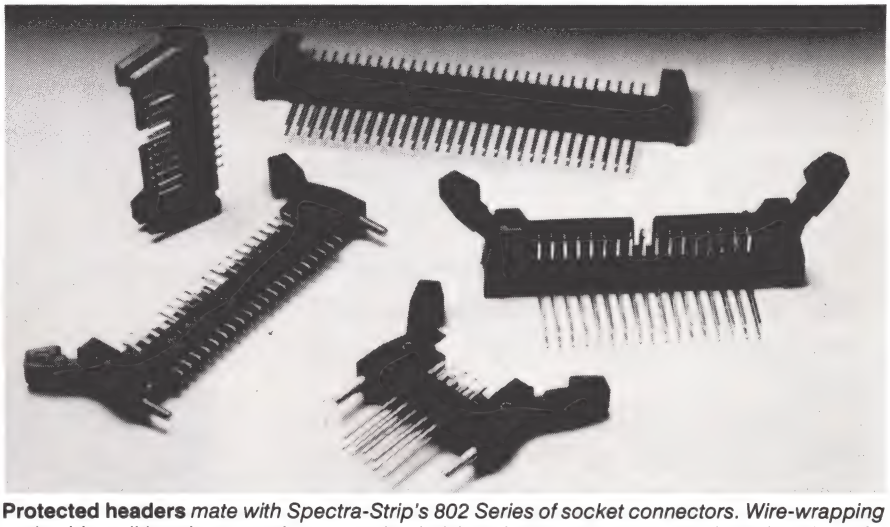
Spectra-Strip's Twist 'N' Flat cable provides a good example of the cost and time savings possible with mass-termination techniques. This cable alternates pairs of 2-in.-long parallel conductor sections with 18-in. twisted pairs. Overall cable performance is comparable with that of conventional twisted-pair cable, and the parallel conductor sections permit termination with IDC connectors.

The company's figures quote about 21 min to prepare and terminate a conventional twisted-pair cable and connector, whereas performing the same task with Twist 'N' Flat takes less than 1 min. Additionally, the labor and materials costs of the Twist 'N' Flat cable are about 36% less than for conventional twisted-pair cable.

Another example of transmission-line cable that can be



PC-board transition connector *from Spectra-Strip mass-terminates up to 50 conductors simultaneously, providing a fixed flat-cable interface rather than the disconnectable interface afforded by a header or socket.*



Protected headers *mate with Spectra-Strip's 802 Series of socket connectors. Wire-wrapping and solder-tail headers contain a central polarizing slot to ensure proper orientation; the units also feature a lock-and-eject feature.*

mass-terminated is T&B/Ansley's Teflon-insulated Micro-Pitch, which consists of alternating signal and ground lines on 0.025-in. centers—half the spacing of most flat cable. During termination, the cable's 20 signal lines (on 0.050-in. centers) are brought out to the Micro-Pitch connector pins, while all 21 ground lines connect to a ground bar with two external contacts for soldering to a common ground.

Another form of flat transmission-line cable is jacketed; that is, it has an additional enclosing plastic sheath. Developed in response to an Underwriters Laboratories specification that calls for jacketing when cables leave one cabinet and go to another, this cable terminates like any other flat cable after you cut off the jacketed portion and expose the flat cable underneath.

For noise-sensitive applications, you can use jacketed/shielded cable. It contains a complete internal shield under its jacket; you must peel this shield back before performing the mass-termination operation. The shield in Spectra-Strip's offering of this type is aluminized Mylar; T&B/Ansley employs a flexible aluminum foil. Separate wires provide an electrical ground connection to the shield in both cases.

The newest manufacturer of jacketed cable is 3M, which has just introduced products functionally similar to those of Spectra-Strip and T&B/Ansley. This company will also soon supply a jacket that can be placed over nonjacketed cable.

The flat connection

About two or three dozen types of flat cable fit the hundreds of available mass-termination connectors. With this large number of termination possibilities, it's best to use compatible cable and connector types from one manufacturer.

The general categories of IDC connectors include:

- DIP-plug connectors

The reliable connection

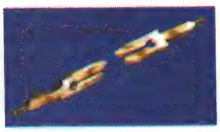
You're looking at a variety of Elco two-piece pc connectors. After you put one on the job, you don't have to keep remembering to check the reliability of the connection. Nothing much is apt to disturb it. Not in most applications.

That's because these two-piece, metal-to-metal pc connectors feature Elco's Varicon™ contacts. Their hermaphroditic fork-like design provides four mating surfaces that wedge together under spring-loaded pressure. Even after years of service and thousands of mating and unmating cycles, a gas-tight connection with low contact resistance is maintained.

The 8223 plug (shown above with wire) comes with a .100" × .100" dual-row square grid and mating receptacle for 1/16", 3/32", and 1/8" thick P.C. board. It's available with 24, 48, 72, or 96 contacts with a choice of terminations: wire wrapping, pc solder tail, wire hole, and wire crimp. Polarity and keying are built into the body to prevent mismating. It's MIL-C-55302 QPL approved.

Other Elco two-piece connectors for 1/16" and 3/32" thick P.C. cards are supplied in popular sizes (6 to 96 contacts), and with popular spacings (.050" or .100" dual row staggered, and .100" single row). They're all competitively priced and promptly available from connector-oriented distributors.

For the names of Elco distributors near you and a copy of our Two-piece pc Connector Catalog, write to ELCO Connector Division, Huntingdon Industrial Park, Huntingdon, Pa. 16652. Tel. 814-643-0700. TWX 510-691-3117.



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Technology News

- DIP sockets
- IC-socket/backplane connectors
- Card-edge connectors
- PC-board solder-transition connectors
- PC-board headers
- Female socket-transition connectors
- Male pin connectors
- D, ribbon and DIN I/O connectors.

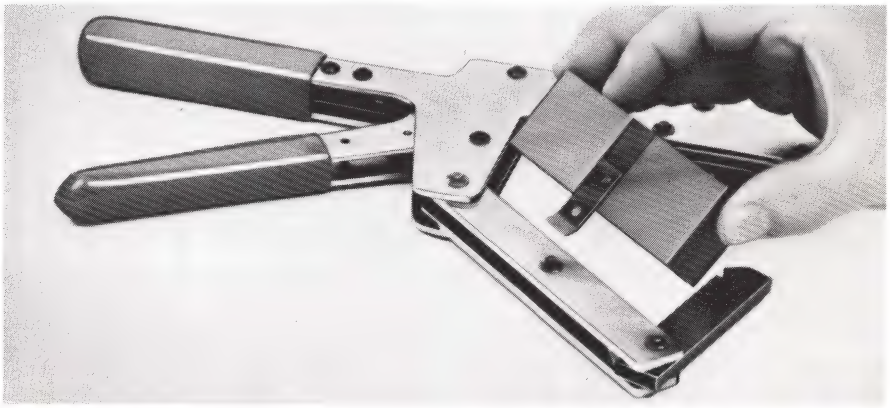
DIP-plug connectors provide a disconnectable interface to DIP sockets. They range in capacity from 14 to 40 pins; some have a strain relief. These connectors permit fabrication of a relatively inexpensive interface for prototype systems employing IC sockets. For mating with one of these DIP plugs, a *DIP-socket connector* can form a disconnectable in-line cable; it can also board-mount to a header.

Another form of *IC-socket connector* inserts over wire-wrapping tails on a pc board or backplane. It provides a simple alternative to the use of discrete wire-wrapped wires running from an IC socket to an I/O connector.

Performing the same function as a conventional card-edge connector, the *flat-cable card-edge connector* comes either with full- or half-mounting ears or with no ears.

Solder-transition connectors provide a convenient means for connecting flat cable to a pc board; you can solder them on a board after effecting a termination to the flat cable, or flow-solder them to the board and then terminate the cable.

For mating with flat-cable connectors, a *pc-board header* mounts to a board, projecting its



Lightweight hand tool *for mass termination of T&B/Ansley flat cable has interchangeable dies to accommodate different types of insulation-displacement-contact (IDC) connectors.*

MANUFACTURER	FLAT-CABLE TYPE	CHARACTERISTIC IMPEDANCE (Ω)	CAPACITANCE (pF/FT)	VELOCITY OF PROPAGATION (nSEC/FT)	CENTER-TO-CENTER SPACING (IN.)	WIRE TYPE
T&B/ANSLEY	#184—JACKETED	110	15.5	1.64	0.050	30 AWG, SOLID
	#177—JACKETED/SHIELDED	52	33.2	1.60	0.050	28 AWG, STRANDED
	#170—MICRO-PITCH	110	12	1.30	0.025	33 AWG, SOLID
SPECTRA-STRIP	#455-240—SPECTRA-ZIP	105	15	1.40	0.050	28 AWG, STRANDED
	#455-044—3C	92	17	1.40	0.050	28 AWG, STRANDED
	#455-248—TWIST 'N' FLAT	105	22	1.70	0.050	28 AWG, STRANDED
3M	#3350—LOW PROFILE	125	12	1.42	0.050	30 AWG, SOLID
	#3365—LOW PROFILE	105	12.6	1.37	0.050	28 AWG, STRANDED
	#3384/50—D CONNECTOR	85	15.7	1.41	0.0425	26 AWG, SOLID

Key flat-cable specs *can vary with construction and manufacturer; they depend on such factors as conductor spacing and diameter and the dielectric constant of the plastic insulator.*

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It's Fluorinert® Electronic Liquid. Non-reactive. Non-conductive. Safe to use. With some unique physical characteristics you'll need for your future technology.

"Fluorinert" Electronic Liquids have gained most of their fame from their widespread use in electronic testing operations. They are now being used widely in vapor phase soldering applications. But they can be used as lubricants. Or non-reactive packaging fluids for delicate instruments. They are currently being used in electro-thermal actuators, baseboard heating safety switches, industrial thermometers, and other applications.

But their unique physical properties may make them useful in many, many more applications. There are eight different "Fluorinert" Liquids offering boiling points ranging from 30°C (86°F) to 215°C (419°F). The fluids offer high dielectric strength, high density, high gas solubility and high coefficients of expansion; and low pour points, low viscosity, low surface tension, low refractive index and low heat of vaporization.

We have literature describing the "Fluorinert" Electronic Liquids, their properties and applications. For more information, write Commercial Chemicals Division/3M, 3M Center, St. Paul, Minnesota 55101, Dept. EDN28.

3M

For more information, Circle No 41

pins either in-line or at right angles to the board. The solder-tail header type mounts and connects to a board through its tail; the wire-wrapping header type has mounting ears, as do some of the solder-tail headers.

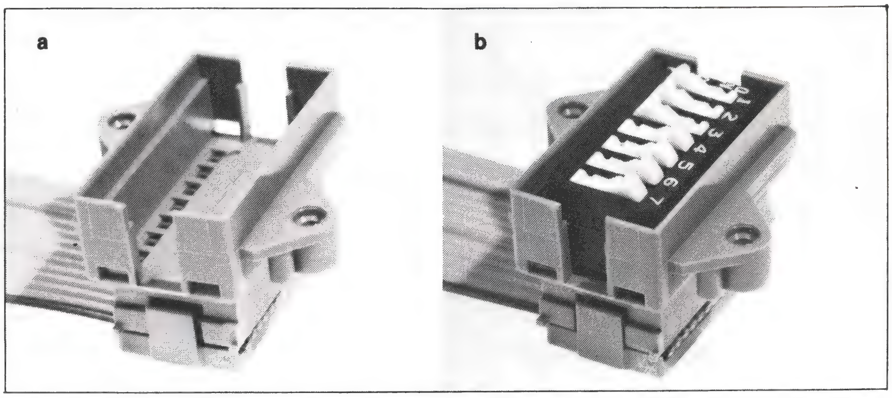
Some headers also provide an ejection mechanism, which simplifies insertion and extraction of the mating connector as well as protecting the pins from bending; others offer retaining clips to hold the mating connector in place. Most headers are polarized to ensure proper pin orientation, and you can choose among open (unprotected) and enclosed (protected) header-pin versions.

For use with board-mounted headers, *female socket-transition connectors* come equipped with either a strain relief or an extractor handle to prevent cable damage. They accept polarizing plugs, and you can also use *male pin connectors* with them. These male connectors come with mounting ears for I/O applications or without ears for in-line cable splices; a strain relief is also available.

Rounding out the list of connectors for use with flat cable are the *I/O types*—flat-cable versions of the D, ribbon and DIN (European Standard Interface Connector) units. The flat-cable mechanical interface allows a maximum of only two rows of pins for these three types of connectors rather than the three rows available—a fact that limits the total number of pins available to a flat-cable user.

What's coming?

With the increased interest in flat-cable systems, you can expect an increased level of product developments. For example, look for an environment-proof type of flat-cable connector; currently, such environment proofing is only possible if you pot the flat-cable/connector interface. Obviously, an arrangement in which environmental sealing occurs upon



Panel-mounted IC socket *(a)* *from T&B/Ansley provides a flat-cable mass-termination capability. It can hold any device that fits into a 14-pin socket—such as a switch, trimming potentiometer or IC **(b)**—and permits convenient mounting and interconnection of parts that might prove difficult to access if mounted on a pc board.*

For more information . . .

For more information on the products discussed in this article, contact the following manufacturers directly or circle the appropriate numbers on the Information Retrieval Service card.

3M Co
Electronic Products Div
3M Center
St Paul, MN 55101
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Circle No 447

Spectra-Strip
7100 Lampson Ave
Garden Grove, CA 92642
(714) 892-3361
Circle No 448

T&B/Ansley Corp
3208 Humboldt St
Los Angeles, CA 90031
(213) 223-2331
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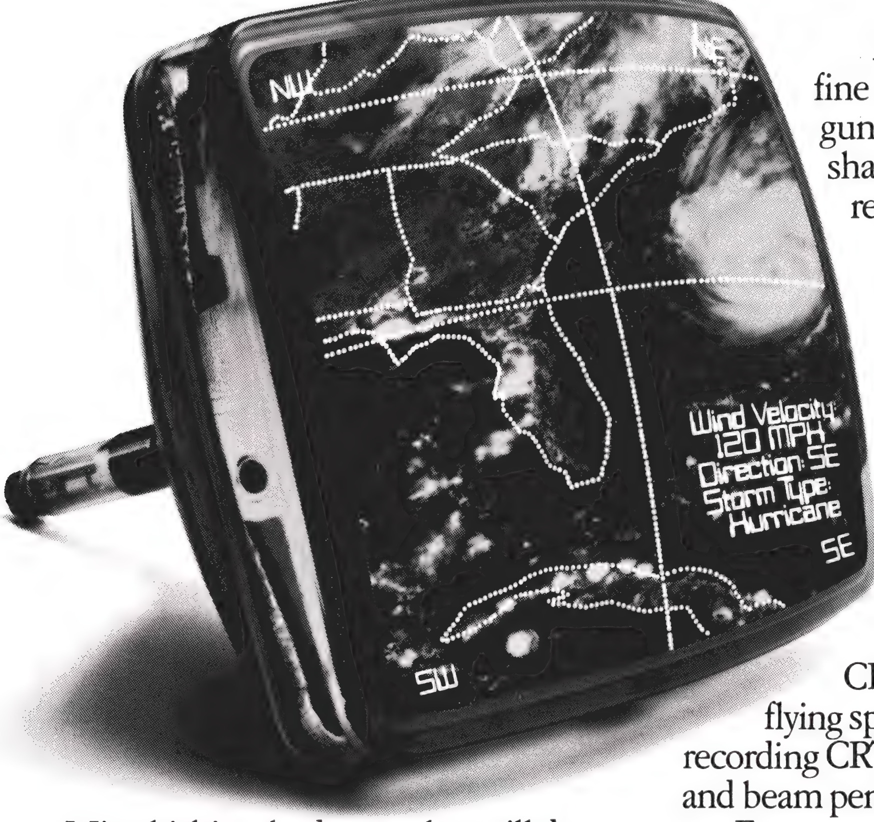

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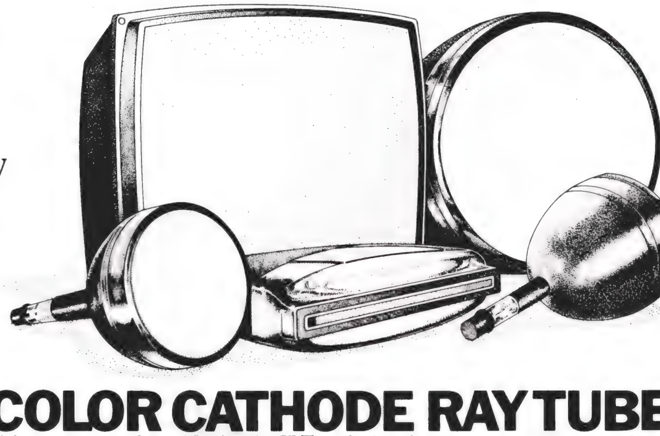
We'll gladly show you a CRT for sore eyes.



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mating is more desirable; a conventional cylindrical MIL-type connector achieves such operation, but a flat-cable version would not necessarily be cylindrical.

Also be on the lookout for flat cables utilizing fiber-optic techniques. (Such systems would require a method of terminating cables in the field or lab without incurring substantial attenuation.) Indeed, 3M already offers a fiber-optic flat cable, although the device does not allow field termination. It consists of a transceiver module that plugs into a special board-mounted header; the flat fiber-optic cable then plugs into a connector on the module. The cable contains two plastic clad 0.008-in.-diameter silica fibers in a standard 30m length. Only TTL interfaces are available now, although other types will eventually be added.

Yet another development in the maturing flat-cable industry is the issuance of military specifications by the Defense Electronics Supply Center (DESC), Dayton, OH. MIL-C-83503 covers flat cable; 17 slash sheets are in process for specific connectors. For use with these connectors, MIL-C-49055A specifies round-conductor unshielded flat cable; 10 slash sheets are in preparation here. Flat-conductor unshielded cable will be covered by MIL-C-49059A, which is also in process and is scheduled for release this month. **EDN**

You're ready for 16-bit processors, but is your logic analyzer?

Andy Santoni, Western Editor

If you're switching from 8- to 16-bit microprocessors in your designs, make sure your logic analyzer can support the move. Although many older analyzers can check out 16-bit systems quickly and conveniently, some can't; if you're now using one of them, you might have to replace it with one of the newer instruments that's specifically designed to handle the peculiarities of 16-bit systems.

Straightforward testing of a 16-bit system calls for an analyzer that displays the μP's instructions in mnemonic form, not just as ONEs and ZEROs. Some analyzers for 8-bit μP systems can handle this chore, but currently, no analyzer can disassemble 16-bit-processor instructions.

Two of the latest instruments, though, will be able to add instruction-mnemonic display for 16-bit devices to their repertoires: Paratronics' System 5000 and Dolch's LAM4850 (sold through Kontron Electronic in the US) provide software-controlled mnemonic conversion that permits such an expansion.

These new machines also have enough input channels to handle the greater demand posed by 16-bit processors. The Dolch/Kontron unit is the record holder with 48 input channels; the Paratronics instrument has a flexible input structure that allows it to handle as many as 40 channels of logic-state data.

Obtain enough channels

An adequate number of input channels is the prime prerequisite for a 16-bit-μP analyzer, says Bruce Farly, product marketing manager at Hewlett-Packard Co's Colorado Springs Div. He maintains that the absolute minimum required is 32 and adds that this number only applies to μPs with limited address space—it isn't large enough for an 8086, for example, which has a

Plug-in boards *allow you to select up to 40 channels of logic-state analysis in Paratronics' System 5000.*

16-bit data bus but a 20-bit address bus.

The 8086's structure calls for a logic analyzer with at least 36 input channels, such as H-P's 1611A, Farly says. Although this instrument was designed for use with 8-bit devices and thus allocates its channels for 16 address bits, eight data bits, eight external bits and four auxiliary bits, you can reassign the channels to accommodate 16-bit-μP systems.

Multiplexing a must

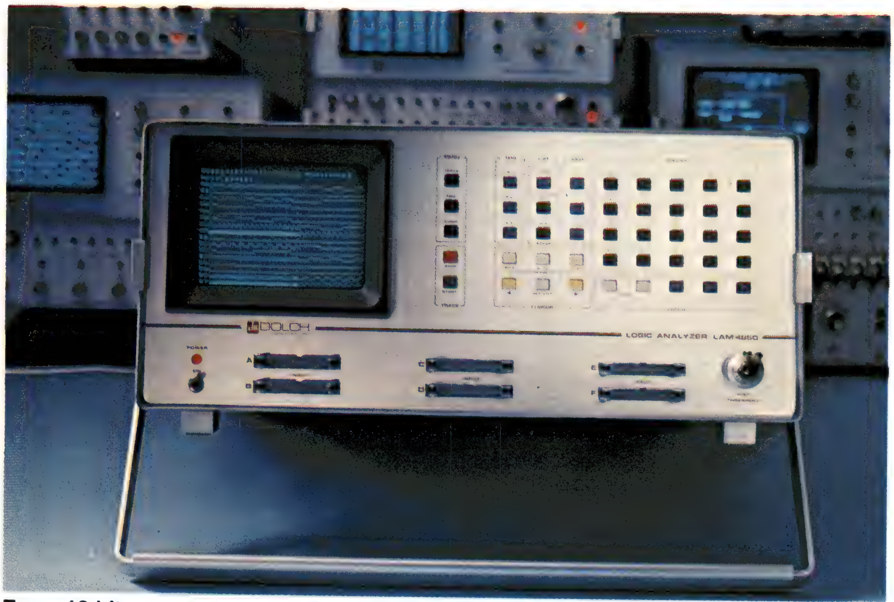
Coupled with the need to keep costs down by minimizing pin count (so that packaging costs are low), the 16-bit μPs' large number of address and data lines mandate multiplexing. Unfortunately, these address and data lines might not line up conveniently: Address bit 1 might not be on the same pin as data bit 1, says Gary Brock, application engineer at Gould Inc's Biomation Div.

On the 8086, for example, the first data line is multiplexed with a memory-select signal—a provision that makes it just a little more difficult to untangle logic-analyzer leads and put the proper bits in the proper locations on the analyzer's CRT screen.

Logic analyzers like Biomation's K100-D can separate address lines from data lines with clock-qualifier circuitry that performs functions such as accepting data only on positive clock edges or only when a specified status line is HIGH. If you only want to examine instructions, for example, you might have to qualify inputs with instruction fetches, Brock explains.

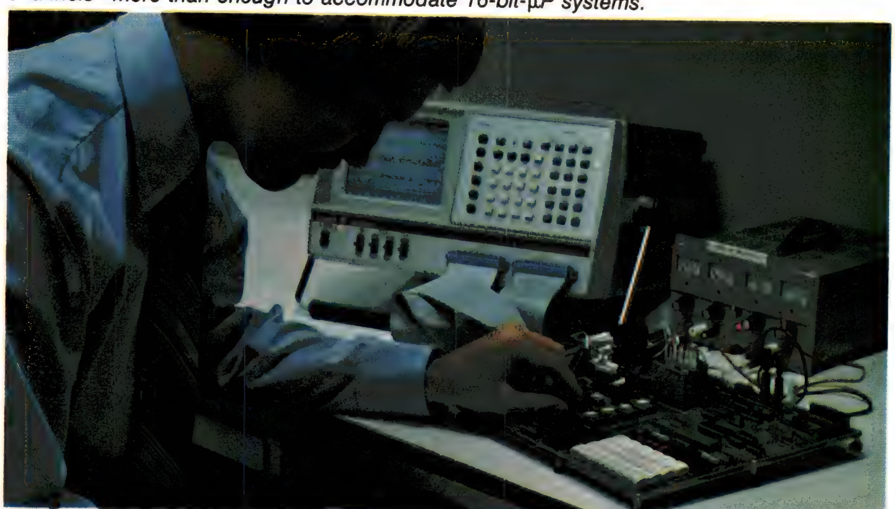
Extendable capabilities

While a 16-channel analyzer like the K100-D or Philips Test & Measuring Instruments' PM 3500 can't perform all the tests you might need for 16-bit-μP systems, it can handle state and timing analysis and glitch catching as easily as in any other digital system.



Even 16-bit processors *don't have too many lines for Dolch/Kontron's LAM4850 logic analyzer to handle. It accommodates 48 inputs at clock rates of up to 50 MHz.*

Logic analyzers are flexible enough *to change input-channel assignments. On Hewlett-Packard's 1611A, you can swap address, data and other lines to configure 36 input channels—more than enough to accommodate 16-bit-μP systems.*



Adapter boxes *ease the switch from 8- to 16-bit systems. While Biomation's K100-D has only 16 lines, a 32-channel adapter for it is available.*

Trigger probes *extend the usefulness of 16-channel analyzers like Philips' PM 3500. This instrument handles up to 56 trigger channels in 8-bit increments.*

For more information . . .

For more information on products described in this article, circle the appropriate numbers on the Information Retrieval Service card or contact the following manufacturers directly.

Gould Inc/Biomation Div
4600 Old Ironsides Dr
Santa Clara, CA 95050
(408) 988-6800
Circle No 340

Hewlett-Packard Co
1507 Page Mill Rd
Palo Alto, CA 94304
Phone local office
Circle No 341

Kontron Electronic Inc
700 S Claremont St
San Mateo, CA 94402
(415) 348-7291
Circle No 342

Paratronics Inc
122 Charcot Ave
San Jose, CA 95131
(408) 263-2252
Circle No 343

Philips Test & Measuring Instruments Inc
85 McKee Dr
Mahwah, NJ 07430
(201) 529-3800
Circle No 344

Then, too, you can extend these 16-channel instruments' usefulness by means of trigger-extender probes; the Philips unit, for example, handles up to 56 trigger channels in 8-bit increments. Similarly, you can extend both trigger and data inputs on Biomation's K100-D with an accessory 32-channel adapter.

In the final analysis, testing 16-bit μPs isn't fundamentally different from testing 8-bit devices, points out Biomation's Brock. "The differences involved in testing two different multiplexed 8-bit μPs are often greater than those for an 8-bit μP and 16-bit unit with similar architectures," he adds.

In this regard, Brock notes that in the past few years, logic-analyzer manufacturers have been supplying products to develop and debug 16-, 32- and even 64-bit-processor systems manufactured by mainframe and minicomputer makers. Typically, these processors employ much higher clocking rates than even the fastest μPs and are constructed using hybrid technologies that require several different logic-analyzer threshold levels. **EDN**


molex

For mass termination component cost savings and applied labor reductions:

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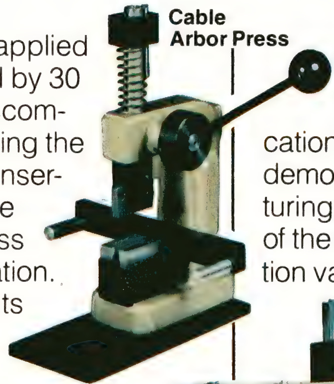
The photo depicts harness and non-harness board .156″ and .100″ center connector versatility. What the photo cannot show is the vast selection within the Molex system including 3 reliable contact designs.

Jet-Flecs .156″ connectors accept wire gauge sizes from 18-28 AWG and Jet-Flecs .100″ connectors accept 22-28 AWG. The Jet-Flecs connectors are drop-in replacements for standard KK* crimp products. There is no need to redesign your present product or application to utilize the advantages of the Jet-Flecs system since the connectors will mate with Molex KK headers accepting round or square pins.

Cost savings up to 40%

When using insulation displacement, your applied costs are lowered by 30 to 40%. This is accomplished by replacing the strip, crimp, and insertion steps with one simultaneous mass termination operation.


Cable Arbor Press

The components and cable are only half the system. The big advantage Molex offers is the complete range of application tooling. This equipment ranges from single wire hand tools to fully automatic assembly machines.

Molex's application equipment is in two main categories, cable assembly and discrete wire assembly.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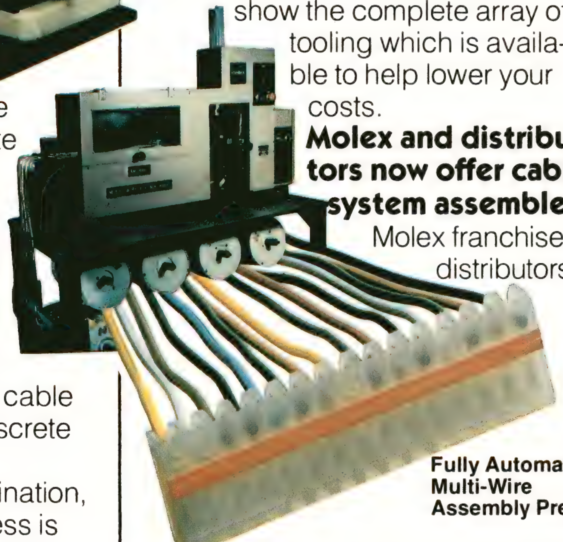
For cable termination, an arbor-type press is available and a semi-automatic terminator for higher production rates.

Discrete wire termination can be accomplished with the use of an arbor-type press, a semi-automatic single wire terminating machine, a harness board assembly tool (which is compatible with your present harness board), or a fully automatic multi-wire assembly press.

Many of these unique application tools are available for demonstration in your manufacturing facility. Or, if you choose, one of the Molex equipment demonstration vans can visit your facility and show the complete array of tooling which is available to help lower your costs.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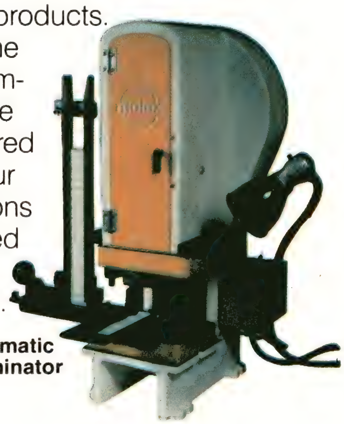
Semi-Automatic Cable Terminator

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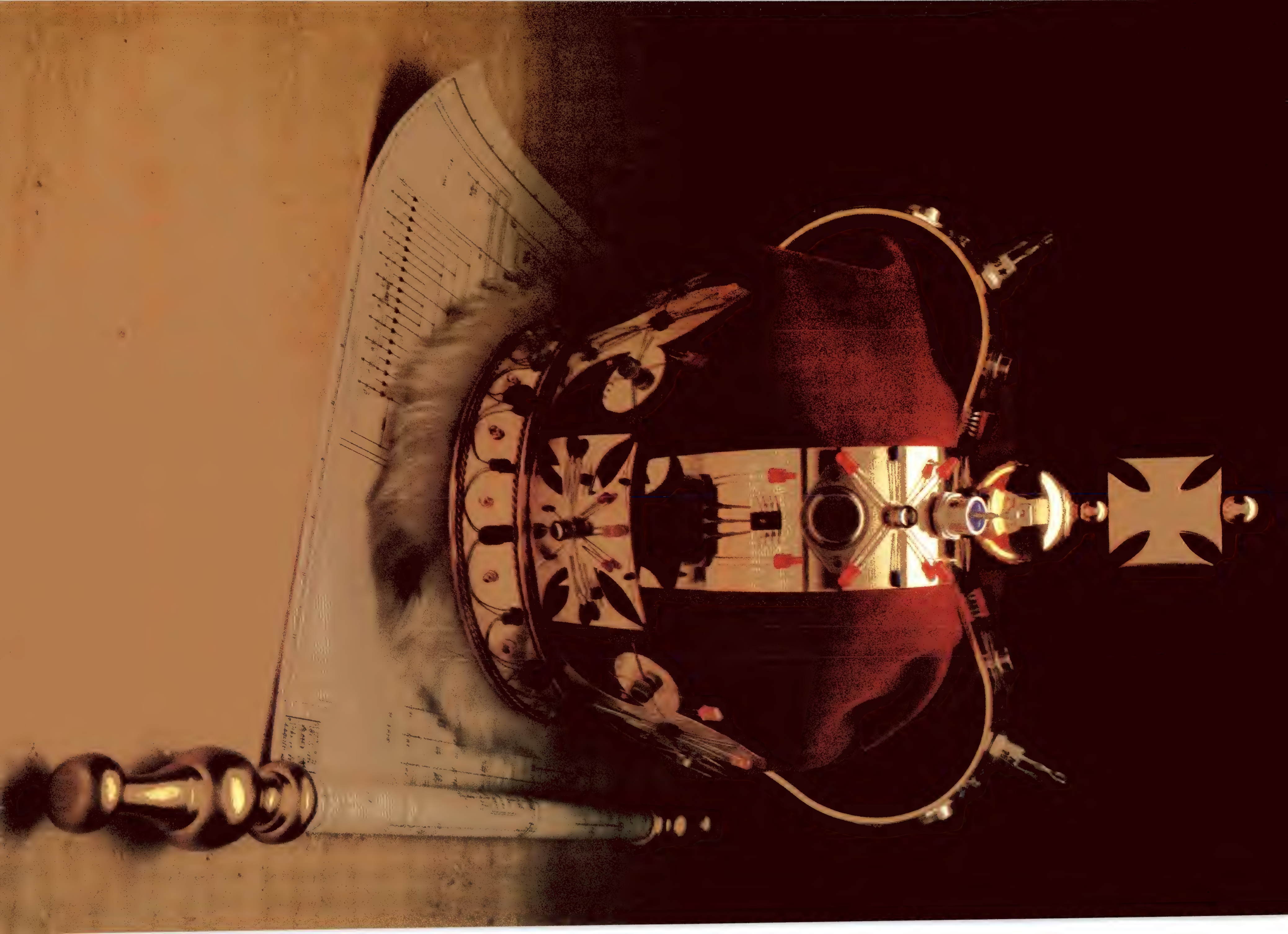

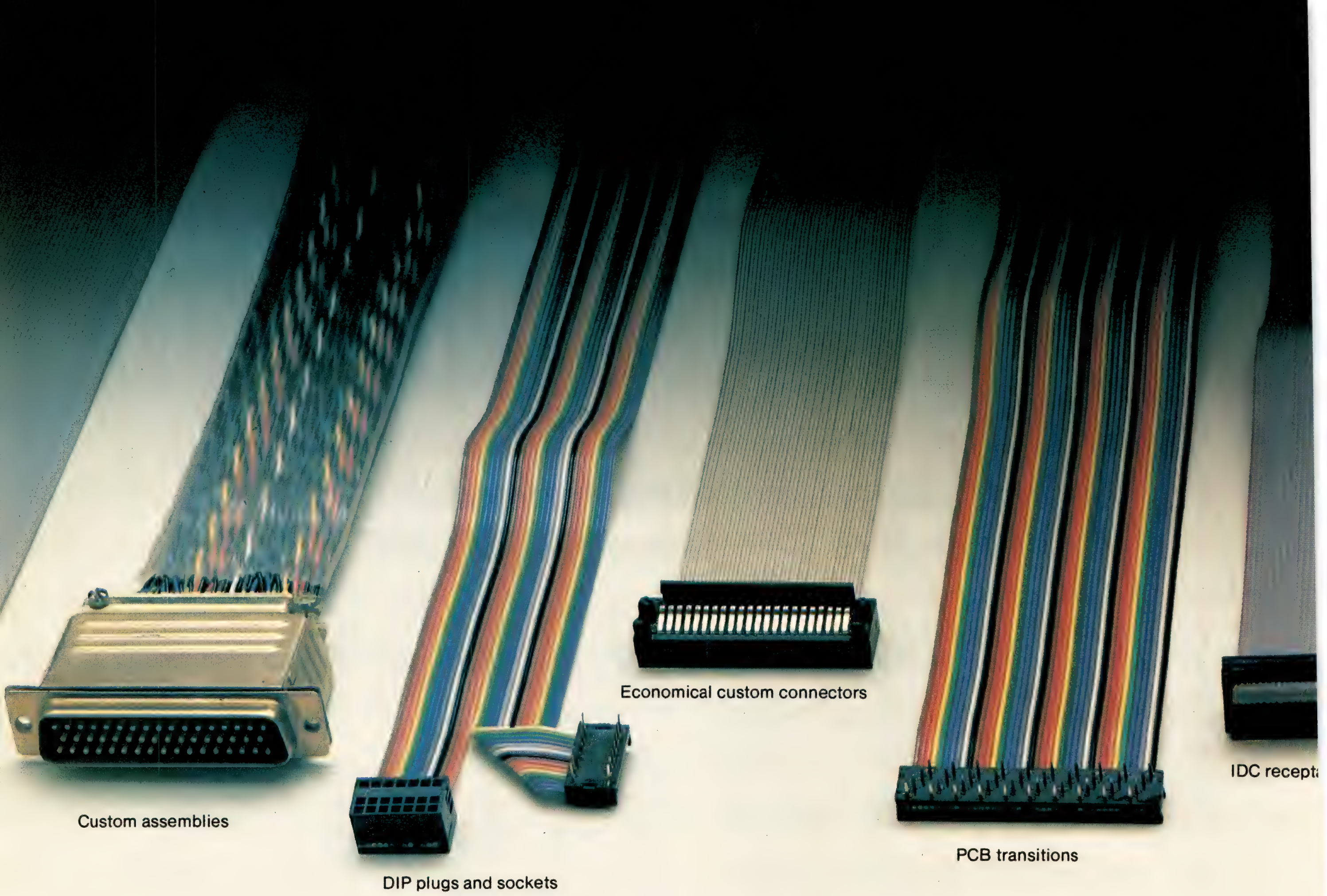

Put an end

IDC mass termination never had it so good, because now you can get all the connectors you need from a single source.

And, if we don't have the standard IDC connector you need to solve your mass termination problem, we'll invent one that will.

We'll take total responsibility for all your interconnect needs from jumpers and flat cables to IDC connectors and ready-to-go custom and standard planar assemblies, so check us out. You'll quickly see why so many happy endings begin with a call to us.

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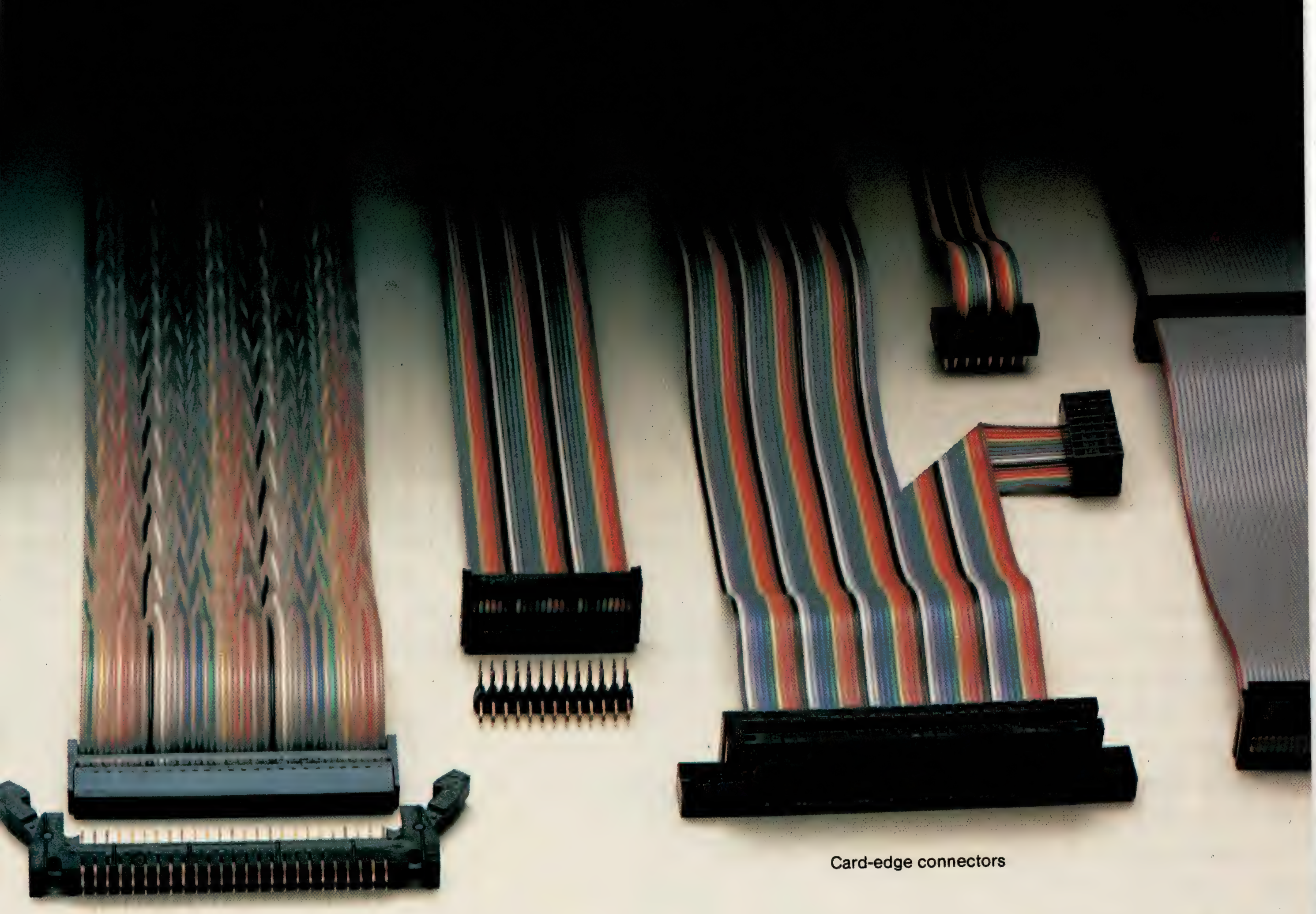


Card-edge connectors

Protected and unprotected pin headers

to it all.

When you're down to the wire

For more information, Circle No 48

For more information, Circle No 49

Editor's Choice: New Products

Hard-disc-based development system eases software/hardware integration

The HP64000 Logic Development System comprises a set of tools that help you integrate software into a µP-based product. It supports up to six stations, each furnishing software-development capability and each configurable into a hardware-development station with the addition of the appropriate emulator, up to 128k of 200-nsec emulation memory and a PROM programmer.

A multiuser operating system provides you with the performance benefits of a Model 7906 20M-byte hard disc (which allows you to back up your files with a 10M-byte removable cartridge) and a Model 2631 printer for hard copy.

Multiuser capability *makes the HP64000's use of high-performance peripherals (such as its 20M-byte disc) economically feasible, thus easing the development task.*

Two beeps means it's working

The 64000 performs a complete self test of its RAM, ROM, keyboard and µP every time you turn on the power, notifying you with two beeps that all is well. If the system passes, its display then describes the current hardware configuration (disc in use, number of stations) and presents a menu of the functions you might wish the system to perform, such as edit, compile, assemble, link or emulate. You activate the desired function by depressing the key immediately below the corresponding screen display. (These keys are termed "soft keys" because system software defines their function dynamically, indicating the function activated on the screen.)

The soft-key concept forms part of the manufacturer's strategy of minimizing the time spent learning to use the system. Operator assistance is also provided by sophisticated prompts from a disc-resident section of the user's manual.

Testing software in real time

System emulation facilities can test the generated code at the highest rated execution speed of each processor supported. The unit's 2-bus architecture permits execution in a prototype independently of the development system's speed limitation. Run and register control furnish complete processor manipulation, including start/stop and examination/modification of register contents. For prototype-memory emulation, the system provides control over address-mapping and memory-configuration parameters such as length and width.

With proper emulator and software selection, the HP64000 allows you to develop systems based on Intel 8080/85, Motorola 6800 and Zilog Z80 µPs. Relocating macro assemblers, trace/debug programs and linking loaders produce the code for the target µP. To simplify the code-writing stage, a "friendly" editor lets you perform sophisticated editing chores with one keystroke.

Programs such as RESET and RECOVER attempt to ensure that the mistakes you make are not fatal. RECOVER, for example, lets you find a previously deleted file, provided you haven't already used that file's disc space for new files.

The basic HP64000 package costs $35,000 and includes a software/hardware development station (with your choice of emulator), 200-nsec emulation memory, 7906 disc, 2631 printer, integral PROM programmer with 2716 personality module, cassette tape and software. Additional software-development stations (up to a total of six) cost approximately $8000 each.

Hewlett-Packard Co, 1507 Page Mill Rd, Palo Alto, CA 94304. Phone local office.
Circle No 455

UNRETOUCHED

MICROPHOTOS

Arrows indicate scars and abrasions made by rough edge of lead frame.

Arrows indicate contact surface still smooth, clean, free from abrasions.

Note rough, jagged edges always present.

22X magnification, unretouched.

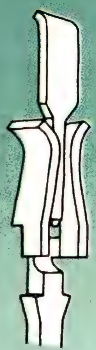
22X magnification, unretouched.

THEIRS

OURS

Your IC lead frames look like this at 30X enlargement (unretouched). Because they are punched out of metal, the edges are rough, jagged and irregular. In contrast, the flat sides of the lead frame are smooth, even and perfectly plated.

An ordinary edge-bearing socket contact after 5 insertions of DIP lead frame. Contact has been spread apart to show inside faces of contact. Notice how the contact has scars and abrasions from *rough, irregular edge of IC lead frame.* Electrical contact is degraded and resistance is increased. Reliability is obviously reduced.

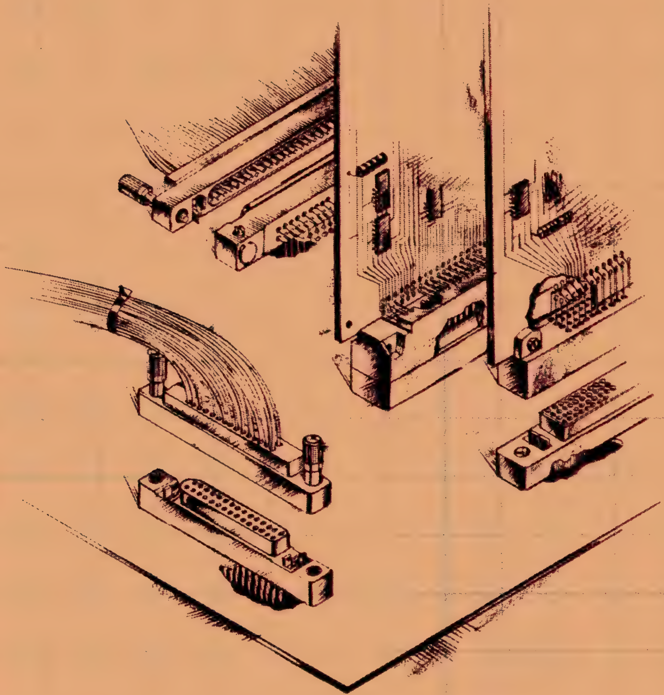


Lead frame in place in an ordinary edge-bearing contact.

ROBINSON-NUGENT "side-wipe" socket contact after 5 insertions of DIP lead frame. Contact has been spread apart to show inside faces of contact. See how the RN contact—because it mates with the *smooth, flat side of the IC lead frame*—retains its surface integrity. This 100% greater lead frame contact results in continued high reliability.

Lead frame in place in RN "side-wipe" contact.

PCB Flexibility with Bendix Brush Connectors.



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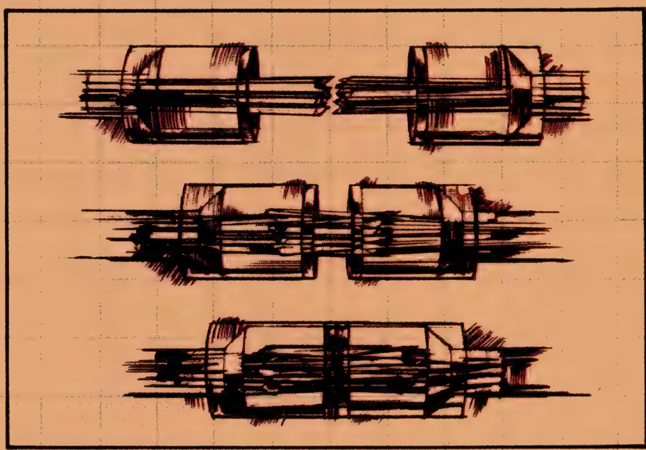

For full information, call (607) 563-5302, or write The Bendix Corporation, Electrical Components Division, Sidney, New York 13838.

Bendix

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For more information, Circle No 51

Editor's Choice: New Products

100-MHz dual-trace oscilloscope features high sensitivity, composite trigger

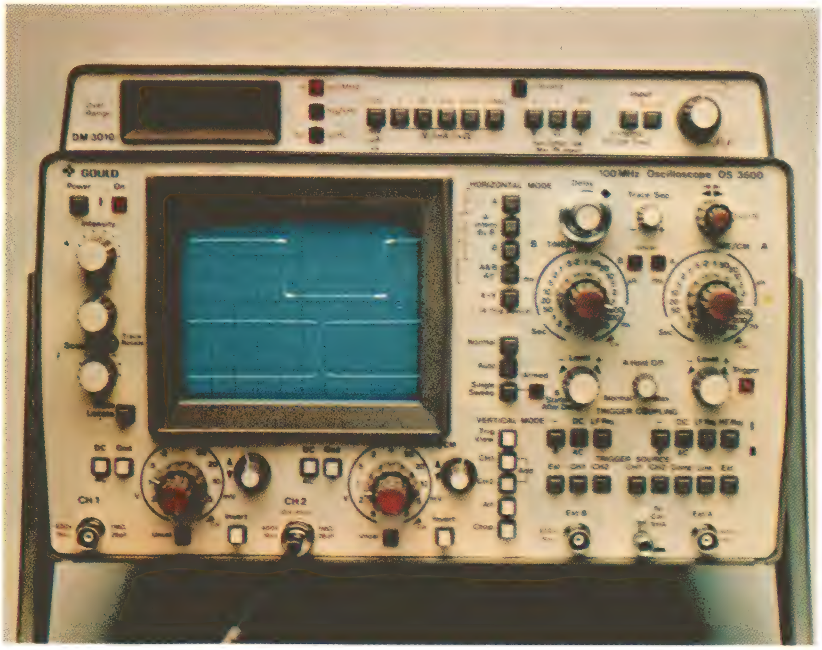
Competition in the 100-MHz-oscilloscope arena got tougher recently when Tektronix introduced its improved Model 465B (EDN, May 20, pg 89). But Gould's Instruments Div feels it can meet this challenge head-on with its Model OS3600. Priced identically to the 465B at $2495, the OS3600 offers:

- Improved sensitivity
- Composite trigger
- DMM add-on with voltage (and time)-measurement capabilities
- Full 2-yr warranty.

Highest vertical-deflection sensitivity on the OS3600 measures 2 mV/cm and remains flat to 75 MHz. It drops to 5 mV at 100 MHz, however. (In contrast, 465B sensitivity specs at a constant 5 mV to 100 MHz.) You get 11 sensitivity ranges in a 1-2-5 sequence to 5V/cm max.

The OS3600's composite-triggering mode is aimed at applications where users are more interested in observing wave shapes than in determining precise time differences. Given two signals of different frequencies, the instrument synchronizes them for display by alternately triggering on one channel and then the other. Additional triggering sources include the standard CH1, CH2, external and line; modes include manual, auto, single sweep and trigger after delay.

A rise time of 3.5 nsec, combined with a third-channel trigger view and hold-off, aid users working on digital systems. And the instrument's 16-kV CRT accelerating voltage provides a bright trace on the



A full 2-yr warranty *on the OS3600 dual-trace scope covers parts and labor and is exclusive only of fuses, minor maintenance and calibration; it's honored at 13 service stations in the US. The $2495 scope is shown here with its $595 DMM option, which can measure the voltages of displayed signals.*

8×10-cm display for investigation of narrow pulses at low repetition frequencies. (Sweep speed of the OS3600 extends to 5 nsec/div, not quite equal to the 2-nsec/div capability of 465B.) Both delayed and intensified sweeps appear simultaneously when you select the scope's alternate-time-base mode.

Eliminating uncertainty

Users requiring high measurement accuracies can order the OS3600's $595 DM3010 option as a factory fit or retrofit. This 3½-digit meter, when used with the scope, measures amplitude (±2%±2 digits), time (±1%±2 digits) and frequency (reciprocal of an equivalent period±1 digit). It can also be operated independently to measure dc voltage, dc current and resistance.

Gould Inc, Instruments Div, 3631 Perkins Ave, Cleveland, OH 44114. Phone (216) 361-3315. **Circle No 456**

NEXT TIME

EDN's September 20th issue will feature a Special Report on pots and trimmers, plus useful and informative articles on

- Applications of a new superfast dual Norton amplifier
- Indexing computer-stored data by means of hash-coding techniques
- The analysis of motor-heating conditions
- The basics of serial data communication
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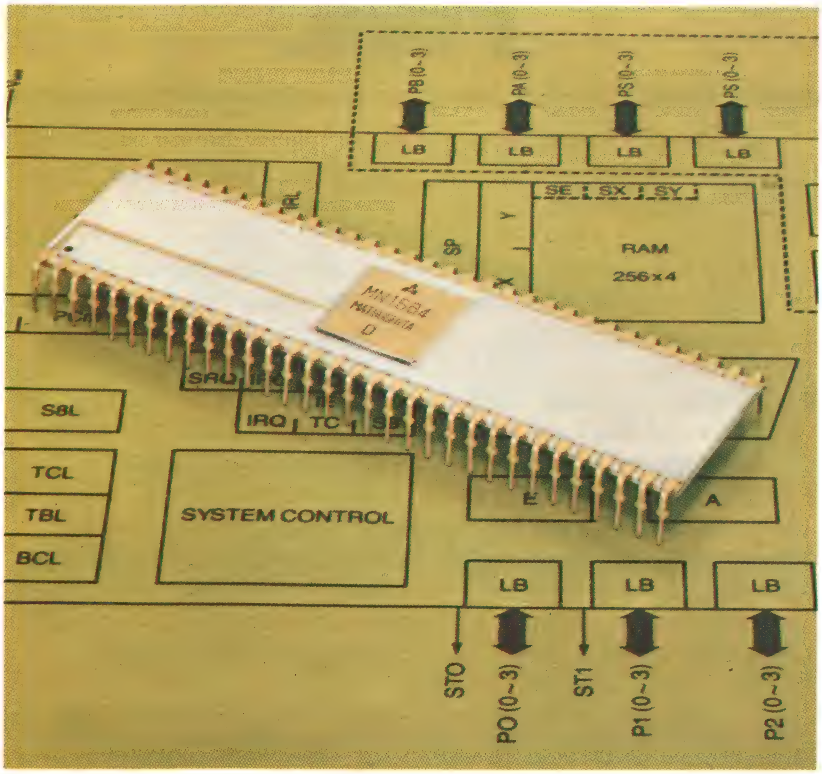
Editor's Choice: New Products

"Super high-level" 4-bit μC performs most processing in 8-bit bytes

Members of the MN1500 microcomputer family might best be described as "bridge" or transition devices because they offer close to 8-bit performance at 4-bit prices. Totally new both in architecture and instruction set, they rely on tight geometries, the n-channel LOCOS E/D MOS process and 3-μm line widths to achieve instruction speeds of 2 μsec. Moreover, they sport either 2k or 4k bytes of on-board ROM, plus 152 or 256 words of RAM, respectively, achieving noteworthy computing power.

Six members constitute the family: Two μCs (the MN1542 and MN1544) come in 40-pin plastic DIPs and feature six bidirectional I/O ports; two others (the MN1562 and MN1564) use 64-pin packages to increase the number of I/O ports to 12. An evaluation chip (MN1599) and companion I/O expander (MN1591) support prototyping efforts and round out the family.



Aimed at use in computer peripherals, *"smart" instrumentation, high-level industrial controllers and sophisticated appliances, the MN1500 μC family incorporates bidirectional I/O ports for flexibility in assigning inputs and outputs. On-chip ROM capacity can range up to 4k bytes; no EPROM version is currently planned. Loop Count and Indirect Jump are included in the family's set of 124 standard instructions.*

Save money, cut power

Pricing for the μCs starts at less than $7 in quantities of 50,000—not overly high considering the chips' memory capacity, speed and computing capability. Key architectural features include 4-level priority interrupts, table-look-up function, an 8-bit counter/timer and an 8-bit serial shift register.

For power, devices in the MN1500 family need only a single 5V supply. Moreover, they can operate in a power-down mode to minimize dissipation—data is retained in memory by applying power only to the RAM via the V_{mm} pin.

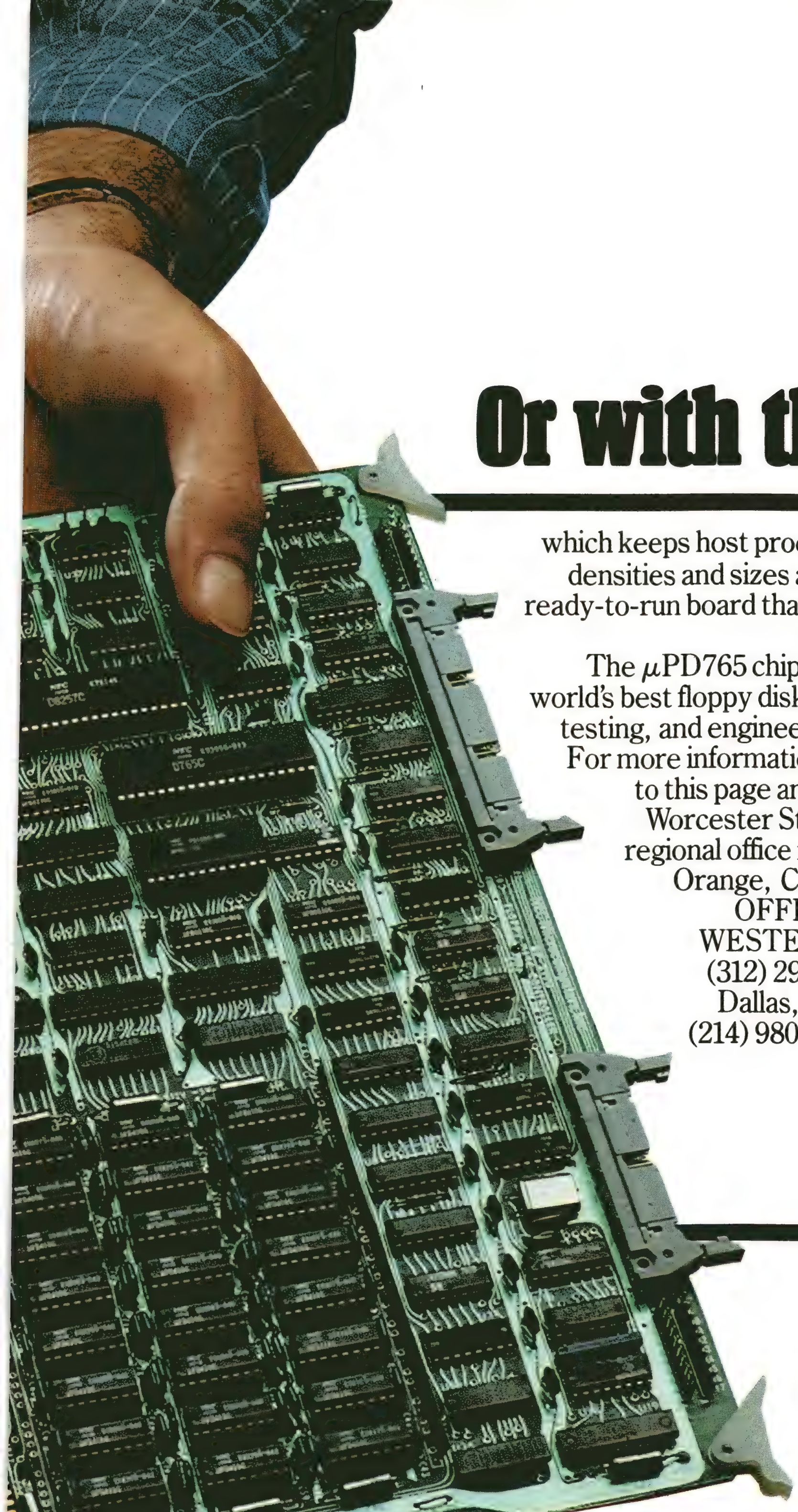
The necessary tools

Support for the MN1500 family will include prototyping boards, emulator boards and a low-cost floppy-disc-based development system. The latter will furnish a resident cross assembler with editing and debugging packages and will be available in November.

The evaluation chip and its companion expander, which cost $125 and $20, respectively, are available from stock. Deliveries of the MN1542, 1544, 1562 and 1564 depend on the overall mask-development cycle, which generally ranges from 6 to 8 wks after receipt of order.

Panasonic, 1 Panasonic Way, Secaucus, NJ 07094. Phone (201) 348-7276.

Circle No 458



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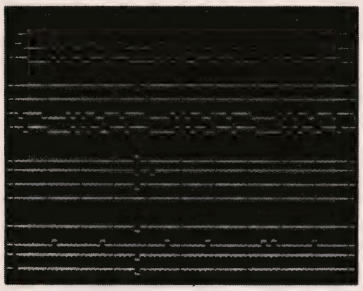

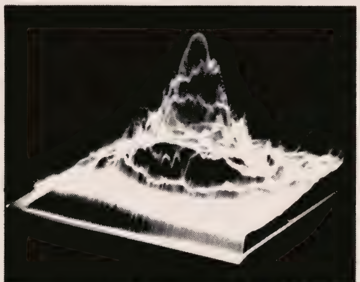

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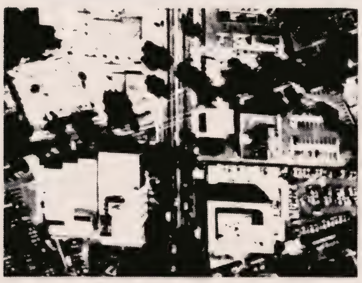

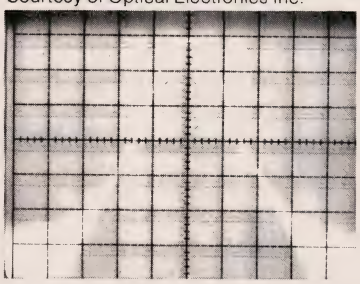

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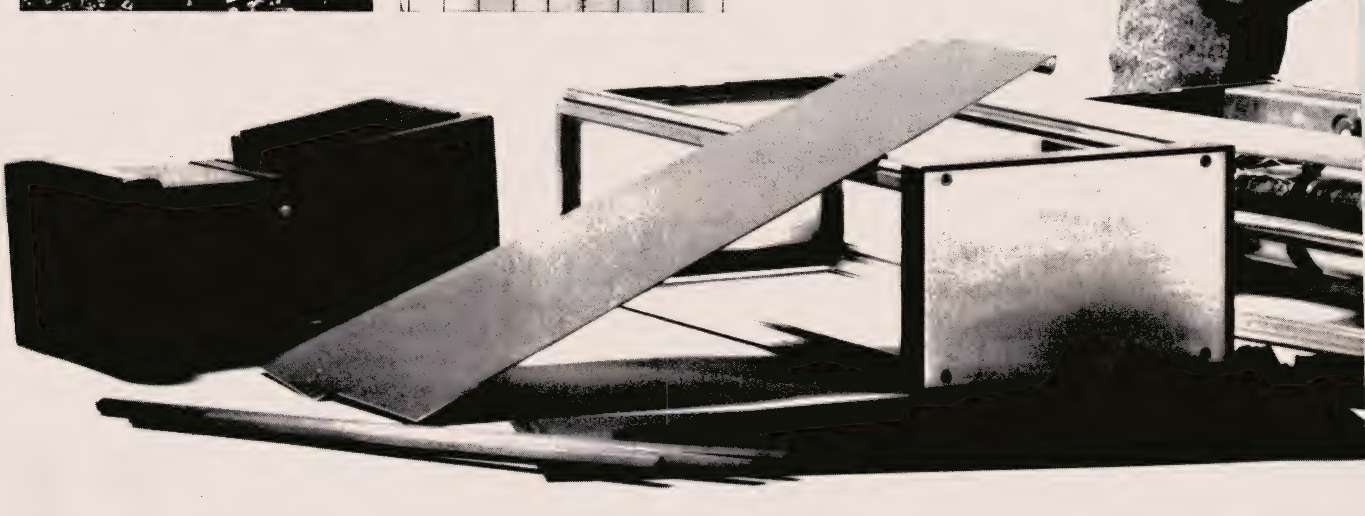

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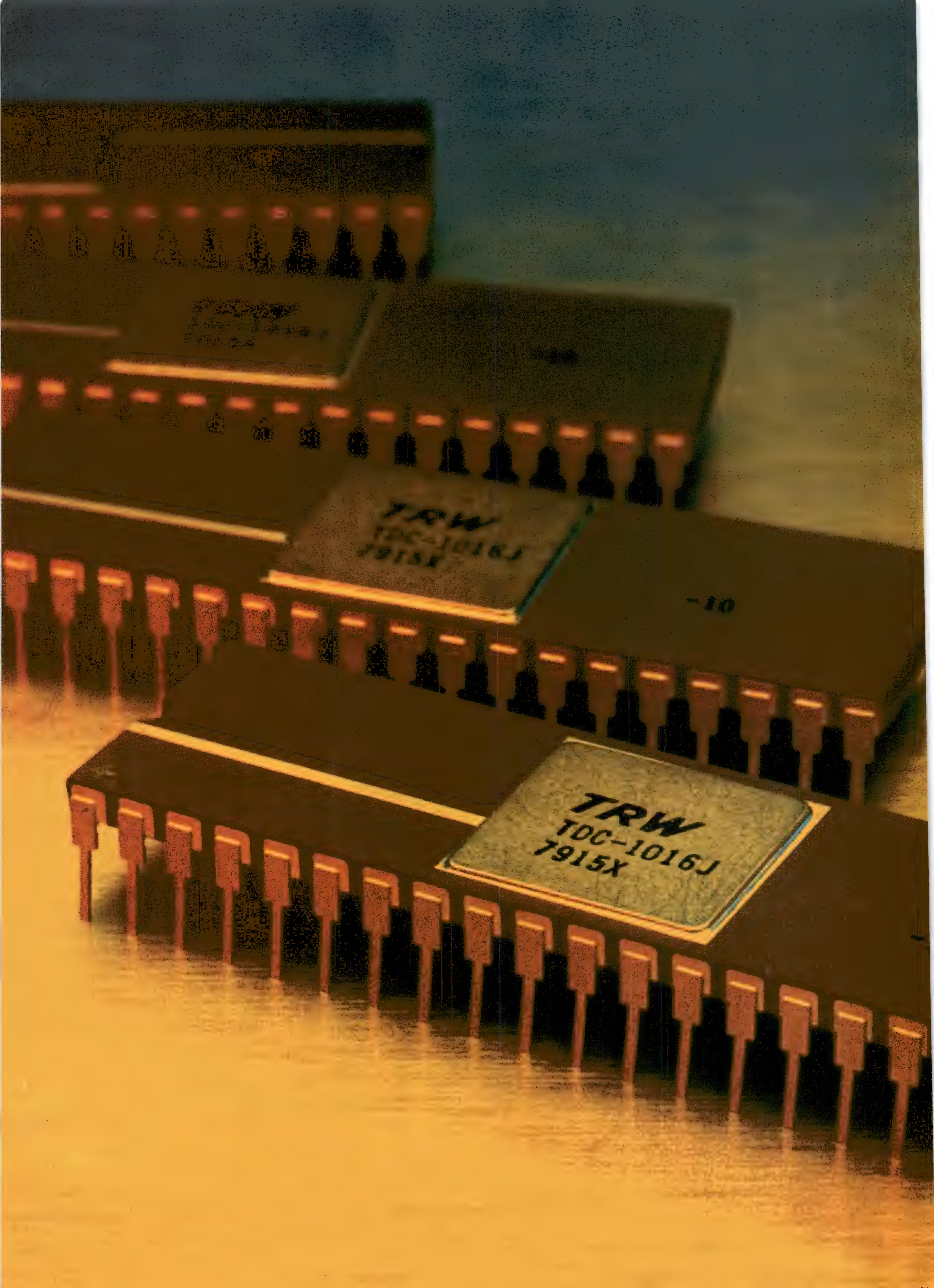
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μComputerist Corner

6502 routines aid debugging

Don Shapiro
American Electronic Laboratories, Lansdale, PA

The 6502 Single Step **(Fig 1)** and Trace **(Fig 2)** programs presented here can save many hours of debugging time by permitting software debugging in a controlled environment. With them, program errors can be detected and corrected efficiently without reloading a program after each error.

The Single Step program permits execution of any software one opcode at a time. After the execution of each opcode, the routine displays the address of the next one. In this manner, software execution can be observed and terminated when an error is detected. This nondestructive software testing permits error correction without inadvertent modification of other memory locations.

Under Trace program control, a sequential record or history of program execution is made available for display. By examining the "trace," you can detect improper branches or exits from loops and monitor loop durations. Bugs are quickly located because intermediate steps of the trace can be overlooked.

Using breakpoints. You can use the breakpoint opcode (00_{16}) of the 6502 in conjunction with the Single Step or Trace programs to produce powerful troubleshooting tools. Single Step and Trace normally make each user-executed opcode available for display. But by placing breakpoints in the user program, you can display just the opcodes following those breakpoints. Because only critical opcodes appear, rapid examination of program branches and loops is possible.

For example, consider inserting breakpoints into

HEX ADDRESS	HEX CODE	LABEL	OPCODE	OPERAND	COMMENTS
0000		LOW			NEXT ADDRESS LOW
0001		HIGH			NEXT ADDRESS HIGH
00E2		USER L			FIRST ADR USER LOW
00E3		USER L			FIRST ADR USER HIGH
00E4		SP			STACK POINTER STORAGE
NMI/IRQ	48		PHA		PUSH A ON STACK
	8A		TXA		EXCHANGE X AND A
	48		PHA		PUSH X ON STACK
	98		TYA		EXCHANGE Y AND A
	48		PHA		PUSH Y ON STACK
	BA		TSX		PUT STACK POINTER INTO X
	BD 05 01		LDA	0105,X	GET OPCODE ADR LOW
	85 00		STA	LOW	STORE OPCODE ADR LOW
	BD 06 01		LDA	0106,X	GET OPCODE ADR HIGH
	85 01		STA	HIGH	STORE OPCODE ADR HIGH
	86 E4		STX	SP	STORE STACK POINTER
	38	SC	SEC		SET CARRY
	B0 FD		BCS	SC	JUMP BACK TO SET CARRY
NEXT	A6 E4		LDX	SP	GET STACK POINTER
	9A		TXS		PUT X INTO STACK POINTER
	68		PLA		GET Y FROM STACK
	A8		TAY		PUT A INTO Y
	68		PLA		GET X FROM STACK
	AA		TAX		PUT A INTO X
	68		PLA		GET A FROM STACK
	40		RTI		EXECUTE NEXT USER OPCODE
INITIALIZE	A2 FF		LDX	#,FF	PUT FF INTO X
	9A		TXS		PUT X INTO STACK POINTER
	6C E2 00		JMP	(USER L)	JUMP TO USER PROGRAM

Fig 1—Single Step *goes anywhere in memory for breakpoint operation. Opcode operation requires memory locations controlled by a chip select not common to the application program.*

HEX ADDRESS	HEX CODE	LABEL	OPCODE	OPERAND	COMMENTS
00E0		STL			START TRACE LOW
00E1		STH			START TRACE HIGH
00E2		USER L			FIRST ADR USER LOW
00E3		USER H			FIRST ADR USER HIGH
00E4		TL			TRACE LENGTH
00E5		TC			TRACE COUNTER
00E6		RL			OPCODE REFERENCE LOW
00E7		RH			OPCODE REFERENCE HIGH
NMI/IRQ	48		PHA		PUSH A ON STACK
	8A		TXA		EXCHANGE X AND A
	48		PHA		PUSH X ON STACK
	98		TYA		EXCHANGE Y AND A
	48		PHA		PUSH Y ON STACK
	BA		TSX		PUT STACK POINTER INTO X
	A4 E5		LDY	TC	GET TRACE COUNTER
	BD 05 01		LDA	0105,X	GET OPCODE ADR LOW
	91 E0		STA	(STL),Y	STORE ADR LOW IN TRACE
	85 E6		STA	RL	SET UP OPCODE REF LOW
	BD 06 01		LDA	0106,X	GET OPCODE ADR HIGH
	C8		INY		BUMP TRACE COUNTER
	91 E0		STA	(STL),Y	STORE ADR HIGH IN TRACE
	85 E7		STA	RH	SET UP OPCODE REF HIGH
	84 E5		STY	TC	STORE TRACE COUNTER
	A0 00		LDY	#,00	SET Y TO 00
	B1 E6		LDA	(RL),Y	GET OPCODE
	A4 E5		LDY	TC	GET TRACE COUNTER
	C8		INY		BUMP TRACE COUNTER
	91 E0		STA	(STL),Y	STORE OPCODE IN TRACE
	C8		INY		BUMP TRACE COUNTER
	84 E5		STY	TC	STORE TRACE COUNTER
	C4 E4		CPY	TL	TRACE LENGTH EXCEEDED?
	10 FE	OVER	BPL	OVER	BRANCH IF YES
	68		PLA		GET Y FROM STACK
	A8		TAY		PUT A INTO Y
	68		PLA		GET X FROM STACK
	AA		TAX		PUT A INTO X
	68		PLA		GET A FROM STACK
	40		RTI		EXECUTE NEXT USER OPCODE
INITIALIZE	A2 FF		LDX	#,FF	PUT FF INTO X
	9A		TXS		PUT X INTO STACK POINTER
	A9 00		LDA	#,00	00 INTO A
	85 E5		STA	TC	A INTO TRACE COUNTER
	6C E2 00		JMP	(USER L)	JUMP TO USER PROGRAM

Fig 2—For breakpoint operation, *Trace can go anywhere in memory. For opcode operation, it must go in memory locations controlled by a chip select not common to the application routine.*

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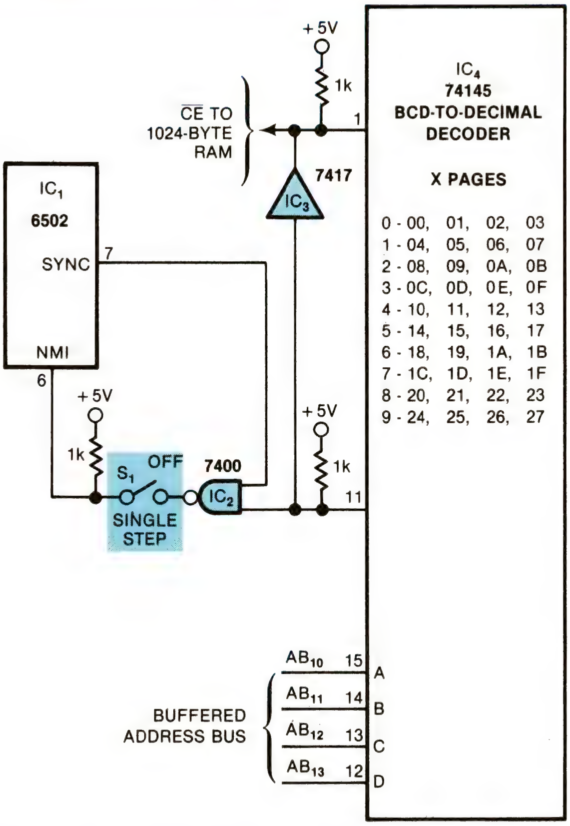

Fig 3—Circuit modifications *are required for opcode/Single Step and opcode/Trace operation. Add IC_2 and S_1 to your existing design; IC_3 is needed only when RAM is limited to 1024 bytes.*

program loops and at each loop exit; Trace or Single Step then indicates an entire loop path with a particular loop exit. Realize, though, that Single Step or Trace will cause the program to resume execution at the breakpoint location plus two bytes. Thus, when a breakpoint is inserted in the user program, the byte following the breakpoint is skipped.

Hardware modifications. The breakpoint/Single Step and breakpoint/Trace programs just described require no hardware modifications; you can use these powerful debugging tools on virtually any 6502-based computer. However, the opcode/Single Step and opcode/Trace programs require minor circuit modifications. The circuit shown in **Fig 3** generates a nonmaskable interrupt (NMI) each time a user opcode is fetched and disables NMIs when the opcode/Single Step and opcode/Trace programs execute. Circuit operation depends on the 6502's generating sync each time an opcode is fetched. The opcode/Single Step and opcode/Trace programs run at any memory location with a chip select different from the memory location of the application program.

In a system with only 1024 bytes of memory, IC_3

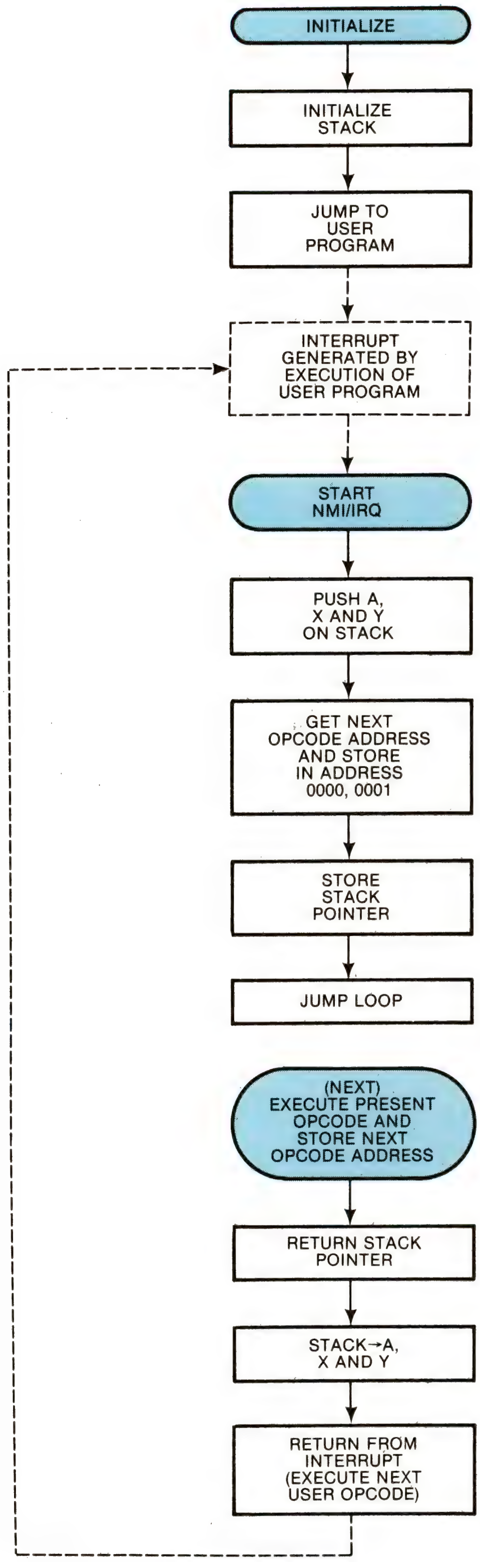

Fig 4—The Single Step routine *allows the application program to run until it encounters a breakpoint or until fetching an opcode generates an interrupt. The dashed lines show the 6502's response to interrupts.*

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allows the Single Step and Trace programs to be loaded on page 03_{16} and executed as if they were on page 27_{16}. NAND gate IC_2 feeds NMI through switch S_1 whenever opcodes are fetched from any pages except 24_{16}, 25_{16}, 26_{16} and 27_{16}. IC_4 is a decoder configured to decode the 10,240 bytes of memory 1024 bytes at a time.

Using Single Step. The flowchart shown in **Fig 4**

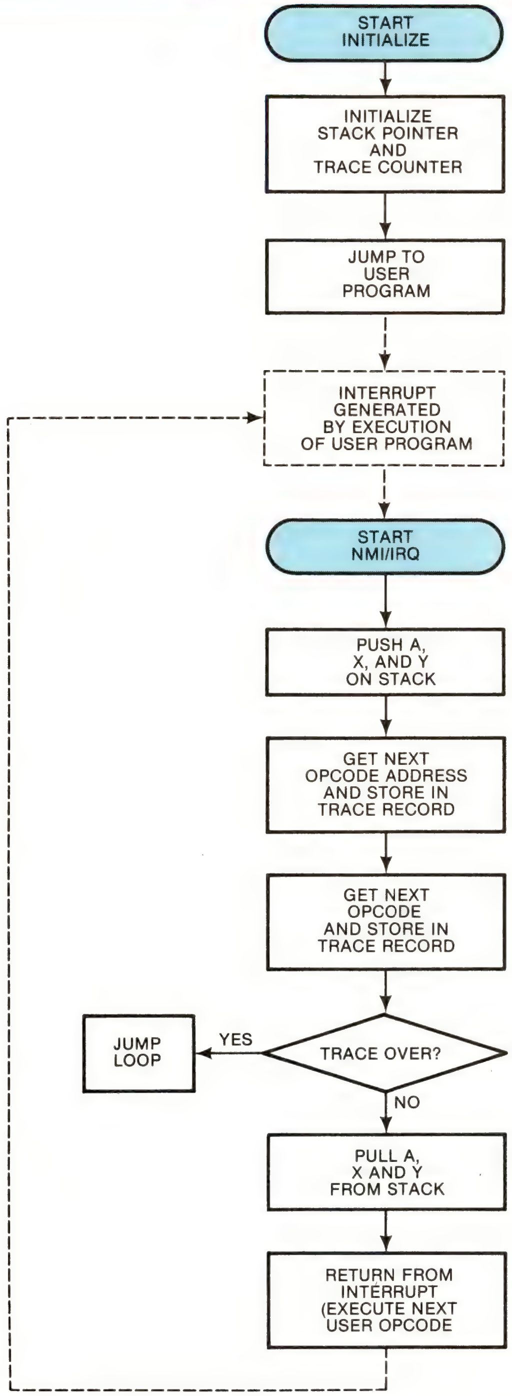


Fig 5—The Trace program *allows the application program to run and keeps a record of every opcode and address or the opcode and address following every breakpoint.*

describes the operation of the Single Step program. To use this routine:

- Operate switch S_1 (in **Fig 3**) to the Single Step position for opcode operation or the Off position for breakpoint operation.
- Set the interrupt vector to the address you have assigned to NMI for opcode operation or to IRQ for breakpoint operation (see **Fig 1**). (Note: NMI interrupt-vector addresses are FFFA (low byte) and FFFB (high byte). IRQ interrupt-vector addresses are FFFE (low byte) and high FFFF (high byte).)
- Insert your application-program starting address into 00E2 and 00E3 (see **Fig 1**).
- Set the reset vector to the address you have assigned to Initialize and execute the Single Step program. (The reset vector is at FFFC and FFFD.)
- Examine the address of the next application opcode in 0000 and 0001.
- Change the reset vector to the address you have assigned to Next (see **Fig 1**); then execute Single Step once for each user opcode. Continue to examine 0000 and 0001 for the address of the next user opcode.

Using Trace. The flowchart shown in **Fig 5** describes the operation of the Trace routine. To use Trace:

- Operate switch S_1 to the Single Step position for opcode operation or the Off position for breakpoint operation.
- Set the interrupt vector to the address you have assigned to NMI for opcode operation or to IRQ for breakpoint operation (see **Fig 2**). (Note: NMI interrupt-vector addresses are FFFA (low byte) and high FFFB (high byte). IRQ interrupt-vector addresses are FFFE (low byte) and FFFF (high byte).)
- Insert your application-program starting address into 00E2 and 00E3.
- Insert trace length into 00E4 and trace starting address into 00E1; trace length cannot exceed $7F_{16}$.
- Set the reset vector to the address you have assigned to Initialize (see **Fig 2**) and execute the Trace program.
- Examine the trace record at the Trace starting address; it's formatted in a repetitive address low-byte, address high-byte and opcode format.

EDN

EDN Software Note #35

6502 routine multiplies signed numbers

Arch D Robison
Lionville, PA

While there are many uses for the multiplication of signed numbers, most 8-bit μPs do not have a multiply instruction. The obvious way to perform a μP signed multiplication is to multiply the absolute values of the factors and attach the appropriate sign to the product. The routine presented here avoids stripping and reattachment of the sign and results in 30% less code and a 10% faster worst-case run time for the 6502 μP.

The basic multiplication loop (TEST through SHIFT in the **figure**) works by shifting bits and adding partial products to obtain the final product, much like base-10 arithmetic performed by hand. Because partial products are always the products of one bit in the multiplier and the multiplicand byte, they will always be either 0 or the multiplicand shifted over the appropriate number of spaces. Here, instead of moving the multiplicand to the left, the product is shifted to the right. The carry from the partial-product addition is shifted into the product.

To restate the preceding witchcraft: Suppose that $J \times K = R$, where J and K are 8-bit signed numbers (2's complement) and R is a 16-bit signed number (2's complement). J is broken into two binary numbers: JL, the lower seven bits, and JS, the sign bit. By the nature of 2's-complement arithmetic, $J = JL - JS \times 2^7$. Consider the two possible cases for K:

1. If $K \geq 0$, $K \times J = (K \times JL) - K \times (JS \times 2^7)$. All that's needed here is an unsigned multiplication of K and JL. If $JS = 1$, then $K \times 2^7$ (K shifted left seven times) is subtracted from the product.
2. If $K < 0$ and K is interpreted as an unsigned binary number, the apparent value will be $K + 2^8$. Thus, the product of J and the apparent value will be $(J \times K) + J \times 2^8$. To get the actual result, $J \times 2^8$ must be subtracted from this product—a process that's equivalent to subtracting J from the high-order byte.

Note that because the range of the factors is −128 to +127, the range of the product is −16,256 to +16,384. Because the range of 16-bit 2's-complement numbers is −32,768 to +32,767, you can safely add two products without overflow unless all four factors are −128.

Additionally, note that you can reduce the average multiply time to 122 clock cycles if you "unroll" the loop and write it out "in line." Although this process increases program length to 82 bytes, it might prove worthwhile if time must be saved. **EDN**

```
                PLIER   =$00        Multiplier- J in text
                CAND    =$01        Multiplicand- K in text
                PROL    =$02        Low byte of product
                                    Enter with multiplier in A.
0200  85 00     MPY     STA PLIER   Store multiplier.
0202  4A                LSR A       Shift out first bit of multiplier.
0203  85 02             STA PROL    Store in low byte of product.
0205  A9 00             LDA #$00    Clear high byte of product
0207  A0 07             LDY #$07    Initialize loop.
0209  90 03     TEST    BCC SHIFT   Test multiplier bit.
020B  18                CLC         If 1, add multiplicand
020C  65 01             ADC CAND      to partial product.
020E  6A        SHIFT   ROR A       Shift product and shift in possible
020F  66 02             ROR PROL      carry from multiplicand addition.
0211  88                DEY         Repeat loop until all 7 lower bits
0212  D0 F5             BNE TEST      of multiplier are tested.
0214  90 06             BCC ADJUST  Test last bit of multiplier.
0216  E5 01             SBC CAND    If 1, subtract multiplicand.
0218  6A                ROR A       Complement carry, since the 6502
0219  49 80             EOR #$80    defines borrow as the complement
021B  2A                ROL A         of the carry flag.
021C  6A        ADJUST  ROR A       Shift product once more and shift in
021D  66 02             ROR PROL      possible borrow from subtraction.
021F  A4 01             LDY CAND    Test sign of multiplicand.
0221  10 03             BPL EXIT    If multiplicand is negative,
0223  38                SEC           then subtract multiplier from
0224  E5 00             SBC PLIER     high byte of product.
0226  60        EXIT    RTS         Return from routine with high byte of
                                    product in A and multiplicand in Y.
                                    Program length: 39 bytes
                                    Time: 178 clock cycles for worst case
                                          138 for best case
                                          158 average for random factors
```

By unrolling the loop *of this 6502 signed-multiplication routine, you can cut execution time to 122 clock cycles.*

Wescon/79 —

Focusing on the latest products and system innovations, this year's show demonstrates the continued interest in μP versatility, instrument developments and more.

The next generation of LSI devices—*exemplified by a member of Fairchild's 100220 8-bit ECL family in a 68-pin leadless package—will be discussed in Wescon/79* ***session 2:*** *"Bipolar LSI for Microprogrammed Machines."*

William Twaddell, Western Editor

The theme is "Gateway to the Eighties." The place is San Francisco. And the technical sessions at Wescon this year will focus on electronics as it moves into the next decade.

Conference subjects will range from designing the next generation of satellite systems to finding super solutions to today's super problems. As in the past, the lion's share of papers will cover μP and μC systems. But now more than ever, promises of "a μP in every pot" gain credibility as designers acquire the necessary information for integrating these devices into their products.

Four of the many sessions of particular interest are:

- **Picosecond Electronics**—If picosecond devices are here now, can femtosecond units be far behind?
- **Bipolar LSI for Microprogrammed Machines**—Nanoseconds are turning into picoseconds as competing technologies and architectures vie for designers' attention.
- **Semicustom Linear and Digital IC Arrays**—The latest improvements in density and functional architecture are speeding semicustom ICs along the LSI highway.
- **IEEE-488: Where Will the Bus Stop Next?**—Taking increased advantage of μP control, the GPIB is getting smarter and solving its problems—but where is the standard ultimately heading, and who is taking it there?

Other Wescon discussions will tell you how to design bubble memories into systems, explain how μPs can aid handicapped learners, describe uses of acoustic imaging

Breaking ground for tomorrow's designs

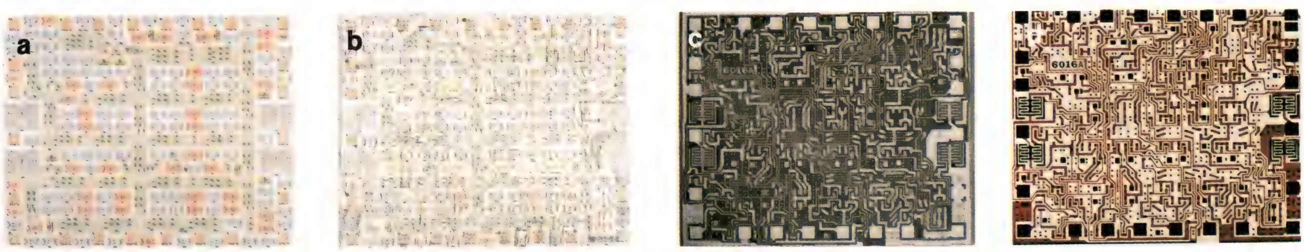
WESCON/79 PROFESSIONAL PROGRAM

	HOTEL ST FRANCIS			HYATT ON UNION SQUARE		
	GRAND BALLROOM	COLONIAL ROOM	CALIFORNIA WEST	PLAZA SQUARE EAST	PLAZA SQUARE WEST	CONFERENCE THEATRE
TUES SEPT 18 10:00 AM TO 12:30 PM	**1.** PRACTICAL TECHNIQUES FOR INTERFACING MICROCOMPUTERS TO THE REAL WORLD	**2.** BIPOLAR LSI FOR MICROPROGRAMMED MACHINES	**3.** RECENT ADVANCES IN PACKET SWITCHING	**4.** SUPER SOLUTIONS TO SUPER PROBLEMS	**5.** SATELLITE SYSTEMS FOR THE NEXT DECADE	**6.** MICROCOMPUTERS AID THE HANDICAPPED LEARNER
TUES SEPT 18 2:00 PM TO 4:30 PM		**7.** PROGRAMMABLE DEVICES: NEW TOOLS FOR LOGIC DESIGNERS	**8.** IEEE LIFE MEMBER HISTORICAL SESSION	**9.** MEMORIES FOR THE μP AGE	**10.** TOPICS IN DIGITAL IMAGE PROCESSING	**SPECIAL SESSION** IEEE REGION VI STUDENT PAPER COMPETITION
WED SEPT 19 10:00 AM TO 12:30 PM	**11.** DEVELOPMENT SYSTEMS: UNIVERSAL OR DEDICATED?		**12.** BATTERIES FOR MICROPROCESSOR SYSTEMS	**13.** SEMICUSTOM LINEAR AND DIGITAL IC ARRAYS	**14.** COMPUTER SECURITY	**15.** PICOSECOND ELECTRONICS
WED SEPT 19 2:00 PM TO 4:30 PM	**16.** COMBINED ANALOG AND DIGITAL LSI		**17.** THE IMPACT OF NEW MICROPROCESSORS ON DEVELOPMENT SYSTEMS	**18.** HIGH-SPEED, LOW-COST NUMBER CRUNCHERS	**19.** IEEE-488: WHERE WILL THE BUS STOP NEXT?	**20.** TECHNOLOGY TRENDS IN MODERN RADAR SYSTEMS
THURS SEPT 20 10:00 AM TO 12:30 PM	**21.** THE SINGLE-CHIP MICROCOMPUTERS: WHICH ONE DO YOU NEED?	**22.** MICROCOMPUTERS AND ENERGY CONSERVATION	**23.** INTERNATIONAL SESSION	**24.** PROGRAMMABLE CALCULATORS	**25.** SATELLITE TV AND THE PRIVATE USER	**26.** LARGE-SCALE CAD PROGRAMS: PRESENT AND FUTURE
THURS SEPT 20 2:00 PM TO 4:30 PM	**27.** DESIGNING WITH BUBBLE MEMORIES	**28.** 16-BIT MICROCOMPUTER BOARD-LEVEL PRODUCTS: CHARACTERISTICS, APPLICATIONS, CONFIGURATIONS	**29.** PERSONAL COMPUTERS IN SCIENTIFIC AND ENGINEERING APPLICATIONS	**30.** ACOUSTIC IMAGING		

and digital image processing and cover such timely subjects as computer security, energy conservation and large-scale computer-aided-design (CAD) programs.

Faster than a speeding bullet

In electronics, improvements in the state of the art have always meant faster or smaller devices—usually both. For this reason, designers must think in terms of future requirements and carefully evaluate each state-of-the-art advance in terms of its limitations as well as its improvements over previously developed technologies. Focusing on one such advance, **session**



A semicustom-IC chip *goes through four stages of development: A 200× chip-layout sheet* ***(a)*** *accepts designers' interconnects* ***(b)*** *to form a complete circuit. Interdesign Inc converts the interconnected layout into a 200× precision Mylar version* ***(c),*** *which is then used to make masks that produce the finished chip* ***(d).***

15's look at "Picosecond Electronics" will allow designers to evaluate the special considerations necessary when dealing with multigigabit logic. Chairman Henri Merkelo, director of the Quantum Electronic Research Lab at the University of Illinois at Urbana-Champaign, promises a stimulating session with top people in their respective fields participating.

Dr Robert W Keyes of IBM's T J Watson Research Lab, Yorktown Heights, NY, will present the opening paper, offering a global view of very high-speed large-scale integrated circuits. He intends to discuss subjects such as the physics of miniaturization, technological limitations, suitable materials for LSI and high-speed circuits, and substrates that provide minimal attenuation of broad-band signals.

Three other papers in **session 15** will examine specific technologies in the high-speed field. "Gallium Arsenide FET ICs," for example, will consider some of the fabrication and design choices available to those devices' producers. The paper's author, Dr Paul Greiling of the Research Lab at Hughes Aircraft Co, Malibu, CA, will discuss such decisions as what type of starting materials to use, which lithography method works best and the advantages and disadvantages of various metallizations. Greiling will also examine the whys and wherefores of depletion-mode versus enhancement-mode logic and their configurations.

Silicon is still in the running

Silicon-on-sapphire (SOS) remains the high-speed hope for a future silicon technology, according to Daryl Butcher of Rockwell International, Anaheim, CA. His **session 15** paper, "Silicon-on-Sapphire High-Speed Electronics," reports propagation delays of less than 500 psec using devices with 2-μm channel lengths and

μC-based devices recapture lost abilities

How would you read a book if you couldn't turn the pages? What if you couldn't see the book? How would you even ask for a book if you couldn't speak?

These are crucial questions for many individuals, and until recently there were very few answers to them. Wescon **session 6** will explore one of the most rewarding computer-application areas, where "Microcomputers Help the Handicapped Learner."

Dr John B Eulenberg, professor of computer science and African languages at Michigan State University's Artificial Language Lab, will present a paper on a "μP-based Portable Talking Computer for the Classroom." The device, termed a semantically accessible language (SAL) board, allows its users to print out or generate spoken English (or any other language whose rules have been coded into a program). While Eulenberg constructed his magnetic-sensor SAL board in the form of a lap tray attached to a wheelchair, the SAL principle applies to many input devices—headsticks, joysticks or touch-sensitive plates, for example.

A nonspeaking cerebral-palsied student *uses his SAL (semantically accessible language) board to converse with a speech pathologist. Michigan State University's Artificial Language Lab developed the board.*

As an aid to people with cerebral palsy or other neurological or neuromuscular conditions who cannot speak, write or use a standard keyboard (and who are often preliterate), the SAL board actually incorporates the rules of English. As Eulenberg explains, "The device doesn't simply talk, it has some linguistic structure driving it."

To operate the SAL board, users point in some manner to symbols on the board, constructing grammatically correct sentences. Touched one way, for example, the device says "I love you"; touched in the opposite manner, it correctly changes the sentence to "You love me."

Improvements in speaking machines stem from researchers' desire to place the disabled learner in a conventional study environment. "Nonvocal Communication/Control Aids in the Classroom and the Job Site," by Gregg Vanderheiden, director of the University of Wisconsin's

100-MHz to 1-GHz frequency ranges. The paper also describes complex analog and digital devices—such as D/A converters—that put SOS firmly in the high-speed ballgame.

Commenting on the very high-speed IC (VHSIC) project proposed by the Department of Defense, Butcher notes that given the way in which this program quantifies performance—number of gates times clock rate divided by chip area in square centimetres—Rockwell has already produced devices in the desired 10^{11}-to-10^{13} range by utilizing 2-μm channel lengths. And the company is currently fabricating devices with submicron dimensions.

Josephson does it at 4°K

Dr Wilhelm Anacker, also from IBM's Watson Research Lab, will round out **session 15** with a talk on the technology that is most likely to develop some surprises in the picosecond-electronics field. Tentatively titled "Ultrafast Computing at 4°K," his talk will cite the advantages of superconducting Josephson tunnel junctions in logic and memory circuitry.

Operating at the temperature of liquid helium, such Josephson devices work at extremely high speeds and consume very little power. Theoreticians expect Josephson switching times—which normally equal less than 10 psec—to drop into the femtosecond (10^{-15} sec) range in future devices. The units' small size and very low heat-generation properties combine to permit extremely dense configurations, thereby shortening the distances between computing elements. Because distance is a critical speed-limiting factor at these high switching rates, such closer packing will help provide the speed gains required by the next generation of big computers.

Although researchers have not completely developed the hardware for a mainframe-sized Josephson machine, they have worked out many of the details of low-temperature computing. Anacker will show several designs and models of Dewar containers—as well as

---

Trace Research & Development Center for the Severely Communicatively Handicapped, will continue the communication discussion with a look at additional improvements.

Communication and control aids comprise three sections, says Vanderheiden: input forms, controllers and output forms. The input form must match an individual's capabilities to provide the fastest means of inputting information. The optimum controller can initiate a series of actions from one command and acts as a buffer to minimize the speed with which users must interface with their environment.

Vanderheiden sees a trend toward single-unit controllers, tailored to the individual, that integrate several output functions. Such controllers cost less than several specialized ones, lighten wheelchair load and permit the use of one control movement—the one the user does best—to control all actions.

To accelerate communications, controllers can output words or phrases instead of letters; alternate functions between communications, wheelchair movement or job-site process control; and automatically handle specific circumstances, such as correcting for the slant in a sidewalk or performing some job process.

Output forms present perhaps the most difficult problems to assistive-device designers. Solutions demand a generalized and easily programmed output aid—a prosthesis-type device that adapts to many uses.

Fortunately, the tendency of unhandicapped persons to build labor-saving devices continues to provide the best source of aids, ideas for aids and—most importantly—lower prices. At Wescon, Vanderheiden will show and comment on available assistive devices, including a recently developed communication control aid termed Autocom.

In a third **session 6** paper, "Toward a Personal Speech-Output Reading Machine for the Blind," Dr Gabriel Groner will describe the reading needs of the blind and some design objectives for machines that meet those needs. Groner's company, Telesensory Systems Inc, Palo Alto, CA, manufactures devices for this field—including a video-to-tactile scanner termed the Opticon—and will produce the University of Wisconsin's Trace Center's Autocom.

One recent device improvement Groner can point to as Telesensory's program manager is a voice-output accessory that reduces the amount of training previously required for Opticon utilization. Users originally employed tactile information to both interpret images and determine the location of the device's camera; this accessory now eliminates the interpretation function by converting video images directly into spoken words. Groner is now developing an automatic book-reading machine that will reduce user workload even further.

If you are interested in assistive devices for the handicapped, you can find more information in *Communication Outlook*, a quarterly newsletter that reports on the application of technology to the needs of communicatively handicapped people. Direct any inquiries to *Communication Outlook*, Artificial Language Lab, Computer Science Dept, Michigan State University, East Lansing, MI 48824.

several types of Josephson chips—and present some of the facts gleaned from extensive research efforts.

Microprogramming means flexibility

Stepping back from the future and into the present, **session 2,** "Bipolar LSI for Microprogrammed Machines," will deal with the latest happenings in high-speed computer logic families. Session chairman John R Mick of Advanced Micro Devices, Sunnyvale, CA, has lined up three papers that cover hardware developments and one that describes software techniques for microprogramming.

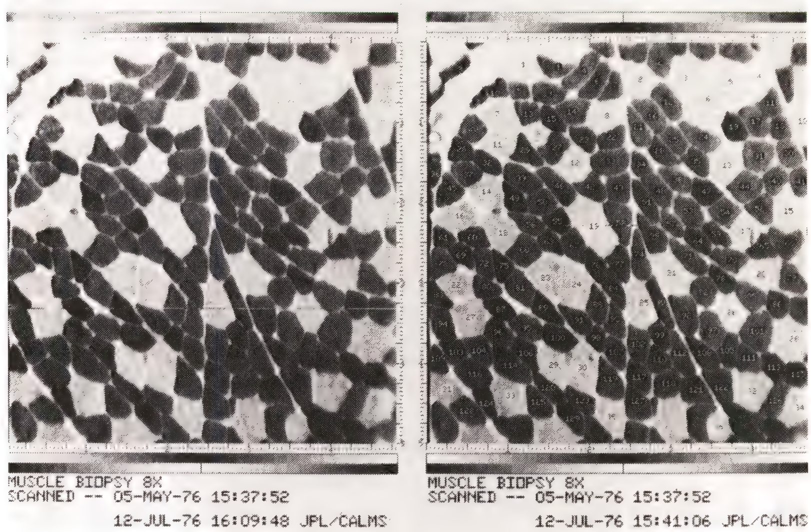
In "A High-Performance 16-Bit Microprogrammed Controller," Bill Harmon, manager of bipolar μP systems and applications at AMD, will announce a new 16-bit μP optimized for controller applications. More than just four 2901s on a chip, the part features preprogrammed bit-manipulation, bit-handling, merging and other control-oriented instructions.

Providing designers with information on what he feels is the next generation of bit-slice machines, Fairchild's Paul Chu will focus on the "Design Philosophy and Architecture of an 8-Bit Microprogrammable ECL Bit-Slice Family." According to Chu, the flexibility of these bit-slice circuits' instruction set, data-path width and system architecture, coupled with recent advances in bipolar-memory technology, makes microprogrammed machines increasingly popular with design engineers.

The image is the message

For most people, the high point of the acoustic-imaging experience is in hearing the beep-beep of sonar on TV programs about submarines. While this first use of sound energy for imaging purposes was important, acoustic technology has come a long way—especially in medical applications.

As part of **session 30**'s coverage of "Acoustic Imaging," Dr Max Maginness, manager of advanced development at Searle Ultrasound, Santa Clara, CA, will talk about the "Medical Applications of Acoustic Imaging." He will comment on some major technical advances that have propelled acoustic medical instruments into the marketplace in the last 3 or 4 yrs. First describing the basic technology, Maginness will then focus on some particular applications of video systems, computers and transducers that suit acoustic systems.



Digital image-processing techniques *developed at the California Institute of Technology's Jet Propulsion Laboratory show the detail in a muscle-fiber biopsy after a computer has found, numbered and measured each fiber.*

Acoustically generated pictures of the human body resemble computer-aided-tomography (CAT) scans, but acoustical units achieve their results in a simpler and more direct fashion by propagating ultrasound pulses in three directions, explains Maginness. Any acoustic discontinuity in the tissue then produces echoes of these pulses.

Because sound travels relatively slowly, acoustic devices can easily time echoes to determine relevant distances. And because a scan's direction through the body is known, the result translates directly into an image. CAT scanners, by comparison, gather X-ray-data projections, which then require complex reconstructions to form a picture. CAT units thus cost up to 10 times more than acoustic equipment.

Acoustic units provide another advantage over CAT scanners. Because different types of tissue—such as that in the liver or pancreas—cause characteristic changes in sound-propagation velocity through the body, details of the sound's echo change with various disease conditions. Thus, physicians not only receive an image that shows the size and geometry of an organ, they also obtain some subtle details that indicate certain disease states. Today, clinicians have reached the point of refining acoustic science to

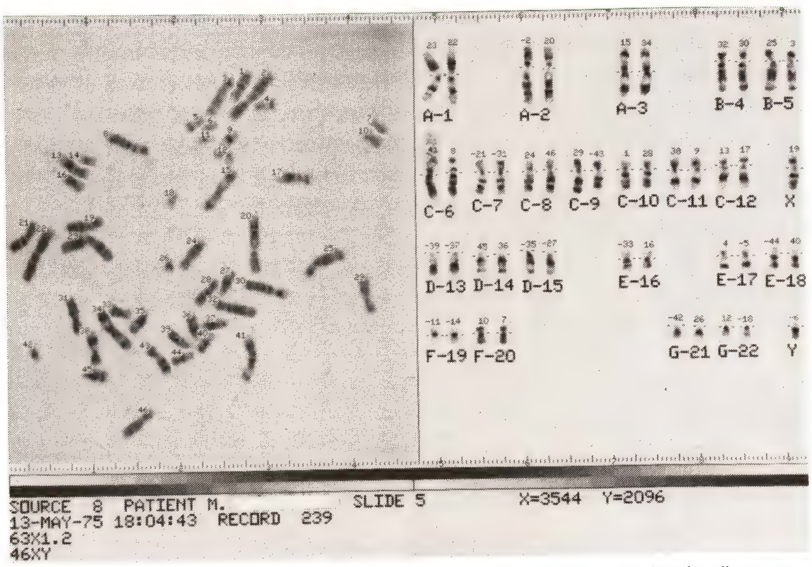
Chu, a senior applications engineer at the Mt View, CA firm, notes that ECL is the highest speed logic family commercially available today—with internal gate delays for F100K logic typically as low as 0.75 nsec. While explaining the nature of ECL bit-slice architecture, he will also discuss error-correction design concepts, the advantages of a 9-bit data path, a system-based philosophy for the device family and possible applications.

The third **session 2** hardware paper, Bill Blood's "M10800 MECL LSI Circuits are Designed for High-Performance Microprogrammed Processors," will also introduce a new line of products. Manager of bipolar-LSI system engineering at Motorola Semiconductor Products, Mesa, AZ, Blood plans to present system examples that utilize the 10800 family. Then, addressing near-term future technology with observations on Macrocell-array design concepts, he will promote these arrays as a viable vehicle for use in custom LSI.

Macrocell arrays will also form the basis of a standard ECL group dubbed the M10900 family. Blood claims a higher density LSI capability and a "quantum jump" in performance when these off-the-shelf products are used in new designs. He adds that his talk will also outline products that apply to microprogrammed processor systems.

Consider software performance, too

Designers must pay careful attention to firmware design to take full advantage of the benefits of microprogramming—that's the thesis of **session 2**'s remaining talk, "Predictive Techniques in Microprogrammed Pipelined Systems," by Max Bar-On. A



A microscopic image of 46 human chromosomes *from a white blood cell appears with computer-assigned numbers on the left. The photo on the right shows the chromosomes after a Jet Propulsion Laboratory computer has located, measured and classified them and arranged them in groups.*

relate fine echo detail to actual physiology.

Considering the number of acoustic-imaging installations in hospitals around the country, Maginness feels that the technique is becoming an accepted medical diagnostic tool. And while there is currently no way to prove that ultrasound is absolutely safe even when properly used, physicians do consider it safer than X-rays. Half of ultrasound's total usage, for example, occurs in examining pregnancies.

Wescon **session 10** also includes a paper that relates to the medical-imaging theme. In "Topics in Digital Image Processing," Kenneth Castleman will discuss the medical successes of more conventional image sources: light microscopes, X-rays and electron microscopes. Castleman, whose group at the California Institute of Technology's Jet Propulsion Laboratory has worked on biomedical image processing for 15 yrs, reports that clinics currently find use for several digital image-processing techniques and that new methods continue to appear.

In the light-microscope area, a white-blood-cell counter is already in the field, and clinics are trying out prototypes of chromosome and muscle-biopsy analyzers. Automated Pap-smear analysis remains in the research stage but offers good possibilities of eventual success.

Clinicians have generally reserved X-ray processing for research purposes, but researchers at the Jet Propulsion Laboratory have developed one heart-disease program that processes blood-vessel X-rays (angiograms) by computer to study vessel narrowing as plaque builds up. Efforts are directed at studying the mechanisms that control the disease's progression and regression.

Lastly, Castleman will survey some of the latest electron-microscope advances. Researchers in this field hope to resolve molecular- and crystal-lattice images to the atomic level, using 2-dimensional Fourier transforms to construct images that extend far beyond the theoretical limits of the microscope itself. Researchers claim, for example, that some existing pictures show the actual carbon and oxygen atoms in an organic-dye crystal.

bipolar-μP development engineer with National Semiconductor, Santa Clara, CA, Bar-On will focus on microprogramming's control operations, noting that these functions are identical for all machines despite task differences. He stresses that while designers give much attention to developing actual data-processing code, design success depends to a large extent on a program's control portion.

Bar-On's discussion will center on predictive programming—a method of speeding up operations in pipelined architectures. At the microcontrol level, efficient pipelining demands that programmers anticipate some number of instructions ahead of time what the results of a particular ALU operation will be. If ALU status determines whether a system must close a door or open a window, for example, but the probability of having to close the door is much greater, the program sends the door-closing command during the ALU operations. When the ALU finishes, the program checks the prediction. If the prediction proves correct, the program continues, having saved some time; otherwise the program turns the predictive command into a NOP and sends out the correct command. This technique works well when dealing with repetitive problems such as array processing or moving large data blocks.

Because real-time systems' needs differ from those of pipelined arrangements, Bar-On will describe predictive circuits to handle real-time requirements as well as other types of problems. A portion of his talk will be devoted to the expected impact of pipelined systems and predictive coding on future microassemblers.

Arrays offer an alternative

Turning from high-speed techniques to high-density circuit-design capabilities, **session 13** will provide a forum on "Semicustom Linear and Digital Arrays" and the technologies used to produce them. Chaired by Derek Bray, vice president for engineering at Interdesign, Sunnyvale, CA, this session will explain how semicustom methods lead to fast design and turnaround times, low cost, low-volume feasibility, design security and flexible architecture.

The semicustom process begins with the fabrication of an IC array of uncommitted components up to the final metal-mask stage. A circuit designer then chooses the chip components necessary to implement a design and draws a diagram that interconnects them. Finally, the semicustom-IC manufacturer translates this diagram into the metal mask that completes the chip.

Representing the standard bipolar and linear portions of the market in "Analog Semicustom-IC Design," Interdesign integration manager Jim Feit plans to review these devices' performance, contents and applications. Noting that most designers still aren't familiar with this alternative to standard and full-custom ICs, he explains that a semicustom-IC manufacturer must establish its credibility with design groups before those groups will utilize array chips with any regularity.

If a design requires more than one semicustom IC, manufacturers can develop multiple chip sets simultaneously—producing a 4-chip interface set, for example. Designers can also opt for a family of devices, starting with a stripped-down model and progressing to full bells-and-whistles versions. Feit points out that the numerous components in one array—almost 450 of them—permit single-chip designs that include up to six op amps or (in one case) two voltage regulators, two op amps and three comparators.

CMOS arrays meet digital needs

For Wescon attendees interested in low-power digital circuits, "Digital CMOS Gate Arrays," by Dr Charles A Allen, president of Master Logic Corp, Sunnyvale, CA, will spell out the advantages of using metal-gate CMOS masterslices. Allen will stress the reasons for CMOS' acceptance as a general-purpose digital masterslice technology: availability, wide temperature and voltage ranges, low power requirements, reliability, ease of breadboarding and simple gate-level composition.

CMOS gate arrays contain 300 to 600 components; at least one chip includes 32 dedicated flip-flop cells to increase circuit density and reduce design time. Allen expects future devices to incorporate more complex arrays of higher speed circuits. To spur growth in these directions, he sees an urgent need for sophisticated CAD-type computer programs to reduce layout, checking and test times.

LSI density opens new fields

Session 13 includes another speaker who will comment further on future device component counts. In a paper entitled "High-Performance 1200-Gate ISL Array," Steve Lau, strategic marketing manager for Signetics, Sunnyvale, CA, will describe ISL (Integrated Schottky Logic) and compare this logic technology with low-power Schottky and ECL with regard to speed, power consumption and density.

With manufacturers such as IBM stimulating the market (the firm utilizes gate arrays in its System 38), Lau expects a gate-array boom to develop and further expects ISL arrays to assume a leading role in that boom. While ISL masterslices utilize the same basic concept as other arrays, their 1200-gate densities open up a whole new world of LSI possibilities.

ISL chips—like some ECL products—provide three different cell types to ease the implementation of different circuit requirements: ISL gates are the arrays' basic element, but Schottky drive buffers and special TTL-compatible I/O cells are also included. Lau concludes that the inherent ease of using these device structures, combined with a comprehensive design-aids package now in development, should reduce customers'

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Data I/O's System 19 PROM programmer talks back to save you time and money.

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apprehensiveness about this return to gate-level designing.

Wescon attendees who visit **sessions 13** and **2** will note a great similarity between the gate-array approaches taken by Signetics and Motorola. Bill Blood's discourse on MECL Macrocell arrays could fit in either session, as could Steve Lau's ISL talk. In fact, the companies' schemes for producing MSI-level functions (termed macros by both firms) from uncommitted transistor cells are much the same. The major difference lies in the type of customer assistance currently available: Motorola has set up a computer center stocked with CAD programs intended to perform almost all the work of translating circuit diagrams into custom metal masks—including designing interconnects and checking design performance.

Which way for the GPIB?

Four years after its birth, IEEE-488 has established itself as a viable instrument-interface standard. And as with all standards, this one has had its problems. **Session 19,** chaired by James H Geisman, corporate marketing program manager at Tektronix Inc, Beaverton, OR, will expose those problems and suggest appropriate solutions. Three papers will also focus on what future course the GPIB might take.

Tektronix engineer Maris Graube, author of "GPIB: Present Status and Future Directions," sees problems not with what the standard defines, but rather with what it fails to define. He plans to examine the standard's operational conventions covering data and its use by instruments—as well as interface-implementation difficulties and lack of instrument intelligence.

Both Graube and Bruce Gould, an engineer with Wavetek, San Diego, CA, see µPs as a solution to several IEEE-488 problems. In his "Changes in GPIB Instruments and Their Impact on the User," Gould credits dedicated µPs as the source of instrument features previously impossible to implement. Software control improves performance, makes instruments easier to use and provides users with a "virtual instrument"—one that furnishes extra software-based features without the extra expense of hardware implementation.

Another **session 19** paper, "Directions in GPIB Controllers," by Bob Hallissy of Hewlett-Packard's Desktop Computer Div, Ft Collins, CO, reports that the IEEE-488 bus will solve many of the problems facing system designers who must connect instruments and controllers from different vendors. He expects, however, that increasing intelligence in these devices will cause new problems. Hallissy will enumerate the potential problem areas, then predict the trends and directions that GPIB controllers must take to eliminate their weaknesses.

Lowered into a liquid-helium bath, *a Josephson memory device's metal junctions become superconducting. Each memory cell in this 2k-bit IBM chip stores a single quantum of magnetic flux—an energy level of less than* 10^{-18}*J.*

Examining yet another angle of the instrument bus, "IEEE-488 Bus Testing: One Manufacturer's Viewpoint" will analyze current test instruments and controllers in terms of their capabilities and functional modes. Presented by Stanley Kubota and Curt Krueger of Interface Technology, Covina, CA, the discussion will center on a chart delineating capability on one axis and test-control functions plus monitoring/analysis/troubleshooting functions on the other. Capabilities range from simple bus-line toggling to the full computing and I/O power of a minicomputer. Functions covered on the control side include read, write, trigger, poll, compare and status. On the monitoring portion, features such as triggering/recording/display of bus states, types of readout used and troubleshooting capacity serve to classify available products. **EDN**

Article Interest Quotient (Circle One)
High **470** ***Medium*** **471** ***Low*** **472**

Wescon/79 Products

Shielded DMM shrugs off big overloads

Neither strong RF fields up to 450 MHz nor gross voltage overloads stop the Model 2815. Basically a 3½-digit, 0.1%-accuracy battery-operated DMM with liquid-crystal display, it provides 0.01Ω, 100-nA and 100-μV resolution.

Overload protection on ohms ranges allows momentary application of 1000V dc (or ac peak)—or continuous application of +1000V dc, −450V dc or 350V ac—without harm. The 10Ω range can sink 3A momentarily without damage. Current-range protection utilizes both fusing and diodes.

Model 2815's measurement ranges include 100 mV to 1000V ac or dc, 100 μA to 1A ac or dc and 10Ω to 10 MΩ (three of these are low voltage for use in diode checking). $150, including test leads, built-in tilt stand, detailed operating manual and spare fuses.

B&K-Precision, 6460 W Cortland St, Chicago, IL 60635. Phone (312) 889-9087. Booth Nos 1852, 54.

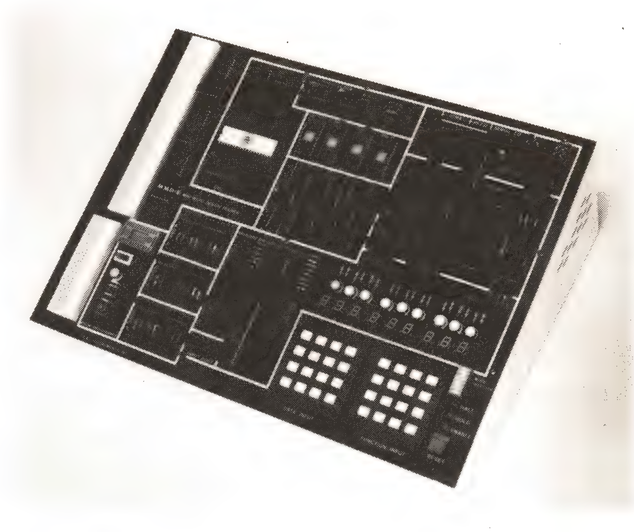
Circle No 441

8080-based μC trainer does double duty

Like its MMD-1 predecessor, the second-generation MMD-2 can serve in dual capacities: both as a trainer in microcomputer utilization, and as a program and interfacing development aid.

Based on the 8080 μP, the unit is fully compatible with Bugbooks 5 and 6 and other company course materials; it also permits the use of user-owned 8080 software. Functions such as serial I/O, added EPROM and RAM, PROM programmer and octal or hexadecimal input and displays are now on-board (they were add-ons for the MMD-1). Also, the MMD-2's fully buffered STD Bus structure permits the use of accessories and peripherals from many manufacturers.

An 8-bit input port and three parallel 8-bit output ports are provided, as are user-accessible binary LED and 7-segment readouts. Separate 16-position keyboards handle function and data entry (switchable for octal or hexadecimal formats). External ASCII terminal control is switch selectable, and five user-accessible priority-interrupt levels are available. $850.



E&L Instruments Inc, 61 First St, Derby, CT 06418. Phone (203) 735-8774. Booth Nos 1822, 24.

Circle No 442

Wescon/79 Products

Minicomputer regulators also isolate

Micro/Minis combine ultraregulation and ultraisolation in a portable, plug-in unit that effectively safeguards precision electronic equipment against nearly all common ac power-line problems except total line failure. Costing much less than a typical dedicated-line installation, they compete in price with ordinary ultraisolation transformers.

Transverse-mode noise attenuation (commonly zero in ultraisolation transformers) exceeds 60 dB, while CMR is better than 120 dB. Output voltage holds within ±3% for ±15% line changes, and the regulated output stays within NEMA voltage specs despite line droop to 65% nominal. The output contains less than 3% harmonic distortion.

You can order UL-listed Micro/Minis with ratings of 140, 250, 500, 750, 1000 and 2000 VA for 60-Hz use, or 500, 1000 or 2000 VA for 50-Hz operation. All units feature audible noise below normal office levels, come with line cord, dual output receptacles and an ON/OFF switch, and operate from −20 to +50°C. $170 (140-VA model).

Sola, 1717 Busse Rd, Elk Grove Village, IL 60007. Phone (312) 439-2800. Booth No 1105.

Circle No 445

Power-line surge protectors work three ways

Designed to provide positive protection from lightning, switching transients and overvoltage, plug-in Models 427 and 428 operate automatically and are self-restoring. Each self-contained device plugs into a 117V±10%/15A single-phase wall socket that accepts NEMA 5-15-type 3-prong connectors.

Three active elements furnish protection: a 3-electrode gas-tube arrester, a thermal circuit breaker and a metal-oxide varistor (MOV). The gas tube quickly shunts short surges to ground; on extended surges it trips the self-restoring thermal circuit breaker. And in cases of severe ac line-voltage fluctuation and/or a high incidence of spikes and transients, the MOV helps reduce their effects and also serves to minimize nuisance tripping of the circuit breaker. $34.75 each. (Model 428 is suggested for applications where ac line-voltage fluctuations exceed 130V rms.)

TII Industries Inc, 100 N Strong Ave, Lindenhurst, NY 11757. Phone (516) 842-5000. Booth No 918.

Circle No 446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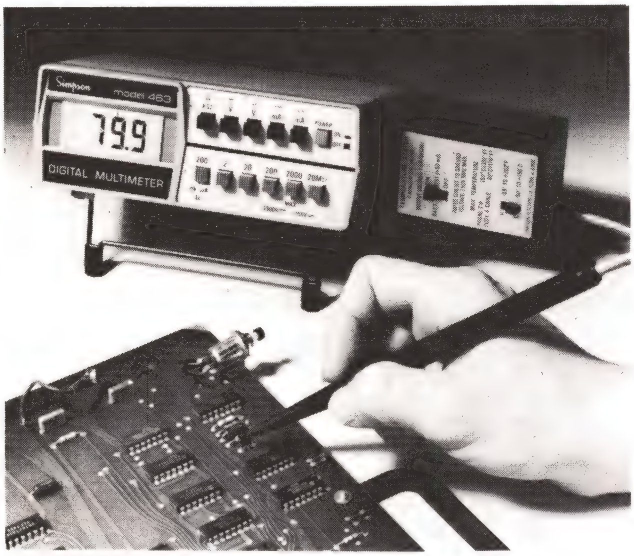
Wescon/79 Products

Temperature probe reads °C or °F



When teamed with any analog or digital meter having millivolt ranges and at least 5000Ω impedance, Model 463 lets you read out temperatures from −58 to +302°F or −50 to +150°C. Each degree change results in an output change of 1 mV.

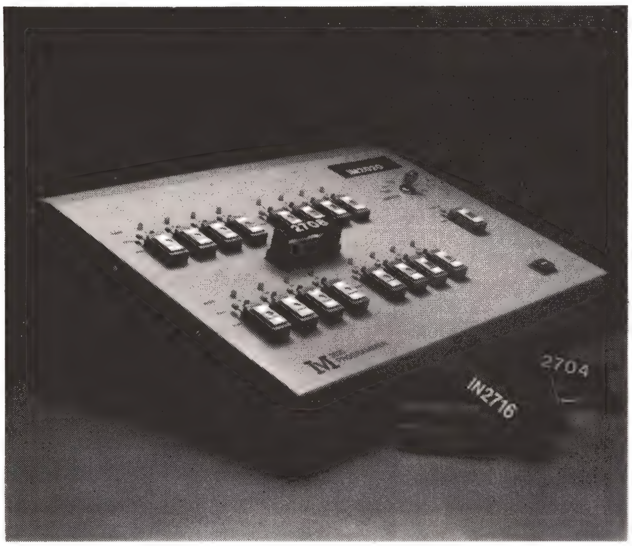
A small solid-state sensor embedded in its tip makes this probe unusually well suited for measuring the temperature of small components, while electrical insulation permits its use in circuits up to 350V dc above ground. The sensor's small thermal mass allows fast settling time (a measurement of a 50°C temperature change settles within 2° in 1.5 sec).

Power comes from a 9V transistor battery, from which you can expect 750 hrs of service. $97.

Simpson Electric Co, 853 Dundee Ave, Elgin, IL 60120. Phone (312) 697-2260. Booth Nos 1421, 23.

Circle No 443

Program 16 PROMs simultaneously



The IM2020 programmer aims at fault-proof operation by nontechnical personnel. It provides single-key operation of all modes, automatically checking PROMs and performing self diagnosis before operations commence.

Other features include a 10-digit alphanumeric display for operator messages, lighted pushbutton operation, a key-lock Mode switch, widely spaced sockets for easy PROM insertion and personality modules for versatility.

The programmer immediately flags its user regarding any bad or partially programmed PROMs, wrong insertions or out-of-spec devices, inhibiting program cycling until errors are corrected.

Currently, you can get personality modules for 2704, 2708, 2516, 2716 and 2532 PROMs. IM2020, $2895 with one module; additional modules, $100 each.

International Microsystems Inc, 11554 C Ave, Auburn, CA 95603. Phone (916) 885-7262. Booth No 1843.

Circle No 444

The snap action switch

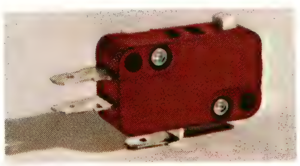
...for **POSITIVE** switching in low energy circuits

Now your 4 to 100 milliampere, 4 to 30 volt circuits can have the same high reliability you've learned to love in Cherry snap action switches. Because, our "heart of gold" snap action switches have the same long life coil spring mechanism, the same large overtravel as all of our snap action switches.

They also have gold crosspoint contacts. A configuration with knife-edge contact area so small (9 millionths of a square inch)...with contact force so great (about 5,000 psi)...and gold alloy so pure and film-free...you are absolutely assured of positive contact every time. For 50 million operations and beyond.

Cherry Gold Crosspoint Contact Switches are available in virtually every snap action design in Cherry's big catalog. And you *know* what a wide variety of switch types, sizes and mounts *that* is. Choose any switch design from a basic open or general purpose to a panel mount pushbutton, low torque, miniature, subminiature or subminiature module. Chances are 99 to 1 that the switch you have chosen is available with gold crosspoint contacts. Which will make designing low energy circuits a whole lot easier...and a whole lot *better.* (No love letters, please.)

For free test sample and complete catalog, just TWX 910-235-1572...or PHONE 312-689-7700.



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Cherry switches now available locally from distributors.

CHERRY ELECTRICAL PRODUCTS CORP., 3603 Sunset Avenue, Waukegan, IL 60085

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For more information, Circle No 70

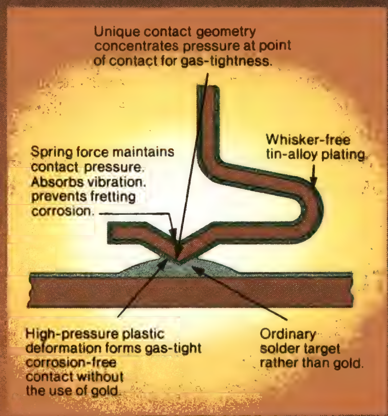

Now, cut ribbon cable
and more...without

connector costs 33% cutting reliability.

Burndy's new GTH™-based IDC II safely eliminates the need for gold in the connector and on the board.

It's the first truly new idea in IDC connector design since ribbon cable itself. And it can cut your connector costs 33% — and more!

The secret? Burndy's patented GTH contact design.



Proven in thousands of dry circuit applications and millions of terminations — GTH contacts deliver gas-tight, high-pressure, good-as-gold contact — even under adverse environmental conditions. Without gold — either in the connector or on the target!

Results? You enjoy all of the savings you get from ribbon cable instead of plowing them back into increased connector costs. And, if you're currently using gold on your circuit boards — stop! You can enjoy even greater savings because Burndy's GTH-based IDC connectors work equally well with solder coated circuits. Get the complete story. Call or write: Joe Bradley, Vice President Marketing, Burndy Corporation, Norwalk, Connecticut 06856. (203) 838-4444.

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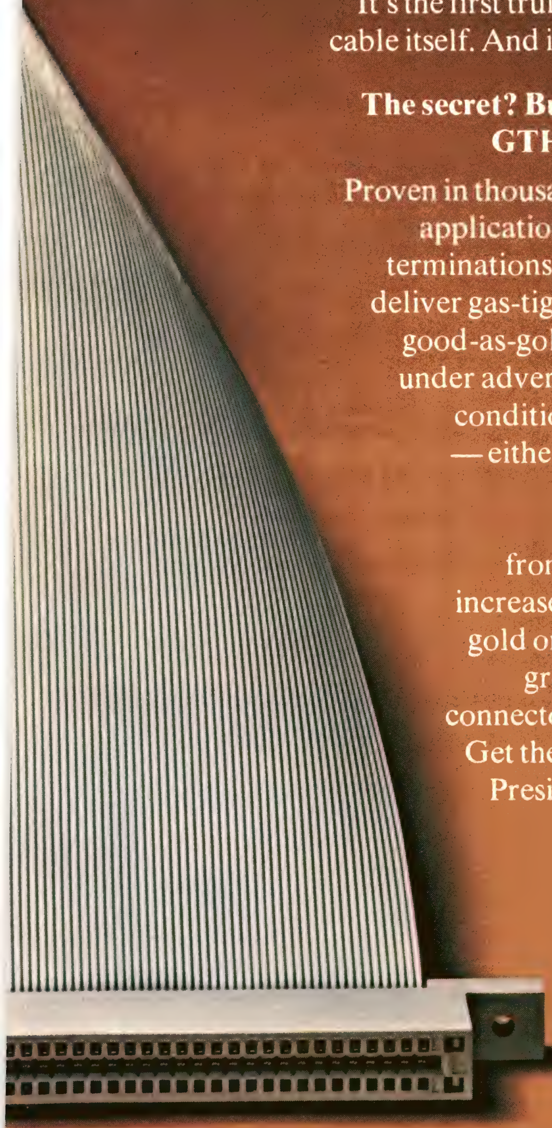

Burndy IDC Connectors.
Card Edge, Header and Socket types. 20, 26, 30, 34, 40, 50 & 60 positions. Meets or exceeds MIL-STD 1344 requirements. Also available with gold contacts.

For more information, Circle No 71

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Wescon/79 Products

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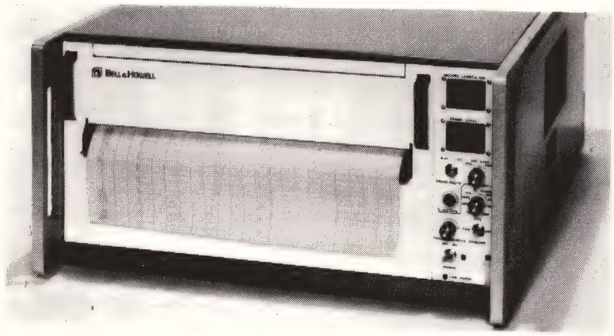


Noteworthy because it employs a programmable light-gate array for recording analog signals on light-sensitive paper, the Model HR2000 DA Datagraph records waveforms having 20-μsec or greater rise times for a 12-in.-wide trace.

By eliminating many of the problems that plague galvanometer and CRT recording oscillographs (such as nonlinearity, overshoot, tangential error, beam deflection, mass, inertia and torque), the HR2000 achieves high fidelity and accuracy. Sine-wave response extends from dc to 5 kHz. $7500 for 8-in. recording; $10,500 for 12-in. configuration.

Bell & Howell, CEC Div, 360 Sierra Madre Villa, Pasadena, CA 91109. Phone (213) 796-9381. Booth No 35. Circle No 345

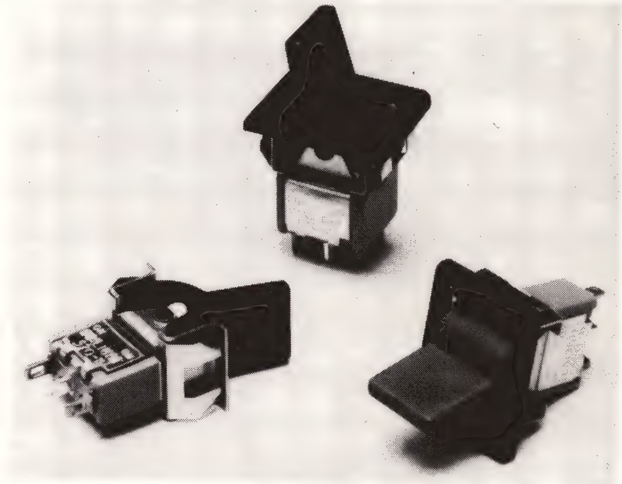
DIGITAL PHOTO TACH

Features such as battery powering, a recall memory, crystal-controlled accuracy and a 15-in. retractile probe cord suit Model 1891 for direct, touchless photoreflective measurements to 30,000 rpm.

To use the probe, you hold it ¼ to 30 in. from a rotating object, pointing the light beam until a built-in "target eye" indicates that contact has been made. You then read rpm directly on the instrument's ⅜-in. LED display. Accuracy specs at 0.03%. The reading updates each second, but the unit's memory holds the last reading indefinitely. $325, including carrying case, 9V long-life batteries and a supply of reflective tape.

Power Instruments Inc, 7352 N Lawndale, Skokie, IL 60076. Phone (312) 676-2300. Booth No 501. Circle No 348

SNAP-IN LEVER SWITCHES



Color appeal makes 572 Series switches distinctive; you can order them with white, black, red, orange, yellow, green, blue, brown or grey molded-nylon actuators and bezels.

Options include spst and dpdt action, as well as nine combinations of switching functions. The series includes units with contact ratings of 0.4 VA max at 20V ac or dc for low-level usage and 5A at 120V ac or 28V dc (resistive load) or 2A at 250V ac for high-level service, as well as a type that handles both high- and low-level switching.

Terminals can be solder- or pc-connection type, with or without epoxy seal. Switches without bezels snap into panels 0.062 to 0.125 in. thick, while the bezel types fit 0.047- to 0.110-in. panel thickness. Cutouts require 0.5×0.6 in. of panel space. From $1.42 (1000). Delivery, 4 to 6 wks ARO.

Dialight, 203 Harrison Pl, Brooklyn, NY 11237. Phone (212) 497-7600. Booth Nos 1113, 15, 17. Circle No 346

BUS EXTENDER

The GPIB-100 has RS-422-compatible line drivers and receivers that allow you to connect instruments separated by up to 300m, instead of the 4m allowed by the IEEE-488 bus. It also expands the maximum number of system components from 15 to 28 units.

In this system, GPIB extension does not compromise bus integrity or performance—data-transfer rate drops only by an amount equal to the 2-way propagation time of the cable. A complete extender system includes two GPIB-100 units and the necessary interconnecting cable. GPIB-100, $995; cable, $10 per meter.

National Instruments, Box 9922, Austin, TX 78766. Phone (512) 837-9546. Booth No 1159. Circle No 347

Wescon / 79 Products

10-NSEC LOGIC PROBE

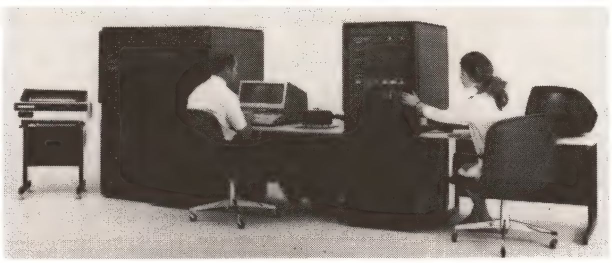
Although it's inexpensive, Model PRB-1 detects pulses with durations as short as 10 nsec and provides frequency response to 50 MHz. Pulse stretching to 50 nsec (plus and minus) is automatic.

The probe offers full compatibility with all RTL, DTL, HTL, TTL, MOS, CMOS and μP logic families. It features 120-kΩ input impedance, power-lead-reversed protection and overvoltage protection to 70V dc.

Supply voltages from 4 to 15V are accepted by constant-brightness LEDs—an optional PA-1 adapter increases this range to 25V. The probe comes with a coiled 6-ft power cord, a complete troubleshooting instruction booklet, tip protector and a reusable case. $36.95.

OK Machine and Tool Corp, 3455 Connor St, Bronx, NY 10475. Phone (212) 994-6600. Booth No 517. **Circle No 349**

BUBBLE TEST SYSTEM

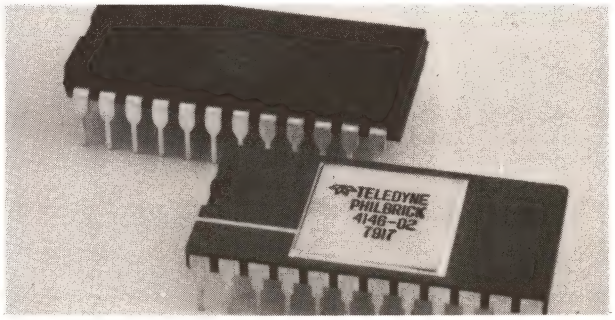


The Model 5585 magnetic-bubble-memory test system handles up to 65M-bit devices and accommodates serial, major/minor-loop, block-replicate and odd/even memory architectures.

Suitable for both engineering and production testing, it incorporates a custom high-speed bubble-memory computer, which generates the necessary complex test patterns. Other features include 6-MHz instruction/execution rate, uninterrupted 1-MHz data rate and standard Xincom III data-bus architecture. Base price for the Model 5585, $89,000. Delivery, 90 to 120 days ARO.

Fairchild Camera and Instrument Corp, Xincom Systems Div, 20450 Plummer St, Chatsworth, CA 91311. Phone (415) 962-3615. Booth No 226. **Circle No 350**

3½-DIGIT CMOS ADC

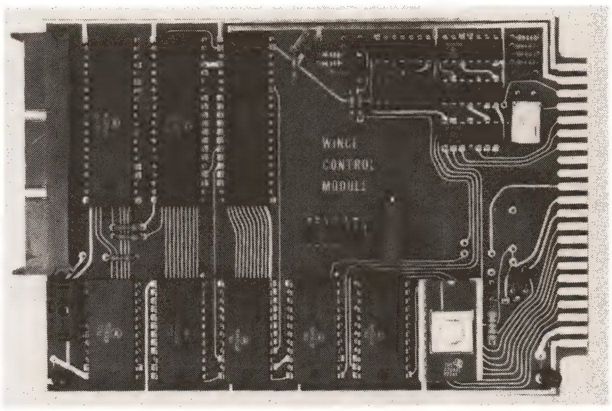


Packaged in a 24-pin DIP, the monolithic Model 4146 employs charge-balancing conversion to achieve high inherent linearity and temperature stability, as well as monotonic operation over its operating-temperature range. In it, an amplifier integrates the sum of the unknown analog current and the pulses of a reference current. The number of pulses needed to maintain the amplifier summing junction near zero is then counted; at conversion's end the total count is latched into the digital outputs as a 3½-digit binary word.

Specifications for the device show ±½-LSB maximum nonlinearity and differential linearity, 20-mW power consumption, compatibility with CMOS/LPTTL/LSTTL and 3½-digit parallel latched output provision. From $12.25.

Teledyne Philbrick, Allied Dr at Rte 128, Dedham, MA 02026. Phone (617) 329-1600. Booth No 1403. **Circle No 351**

SINGLE-BOARD COMPUTER



One 5V supply powers the Wintek Control Module. Furnished on a 4½×6½-in. G-10 pc board with industry-standard 22/44-pin gold-plated edge connector, this 6800-based micro module provides a 1-MHz clock; a baud-rate generator for all rates to 9600; 128 bytes of RAM; a socket for 2758, 2716 or 2732 EPROM; and a choice of one serial or two parallel I/O ports.

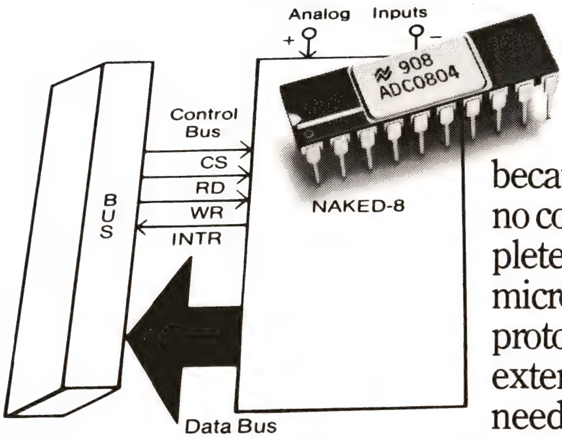
You can expand the module with up to 64k RAM, ROM or I/O using the company's compatible modules. Basic board, $125; $189 with 0.5k RAM, serial I/O and 32 lines of parallel I/O.

Wintek Corp, 902 N 9th St, Lafayette, IN 47904. Phone (317) 742-6802. Booth No 1627. **Circle No 352**

The A/D that transit

brings rapid to the bus.

Introducing an 8-bit A/D converter that gets you a lot more accuracy on any bus for a lot less money and time.



It's called the "Naked-8." So pegged because it performs with no costume at all. It is so completely compatible with microprocessors (i.e., signals, protocol and timing) that no external support chips are needed.

Combine this virtue with a 100 μsec conversion time, an accuracy as good as ±1/4 LSB, a power need of 5V at 1 mA, and a cost as low as $2.95. There's no easier or better way to get to the bus.

The "Naked-8" opens up a whole new world of A/D design applications. Drop us the coupon below and get the complete story on the ADC0801 family.

And start taking the fast route.

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2900 Semiconductor Drive M/S 16250
Santa Clara, CA 95051

Sure, I'd like to be exposed to the "Naked-8." Please send me the facts on ADC0801, ADC0802, ADC0803, and ADC0804.

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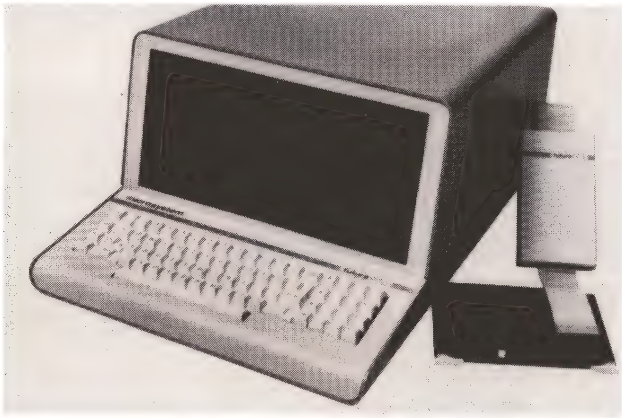
EDN 9/5 9-3

National Semiconductor

HARDWARE/SOFTWARE STATION

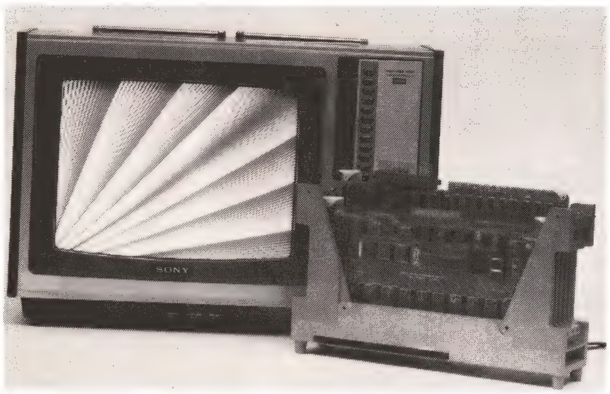


The AMDS-AST provides you with all necessary tools for 8080, 8085, 6800, 6802 or Z80 μP-based product design and testing. A CPU, universal logic analyzer, CRT and keyboard are all integrated into this compact station, which has a built-in high-speed network interface for sharing disc and printer sources.

A real-time in-circuit emulator for the selected processor is included, and the station comes equipped for full use of a complete set of network software. Up to eight AMDS-AST stations can be configured in a network in which each user can develop products based on different processors. $12,500.

GenRad/Futuredata, 11205 S La Cienega Blvd, Los Angeles, CA 90045. Phone (213) 641-7700. Booth Nos 1635, 37; 1736, 38. **Circle No 353**

COLOR MONITOR

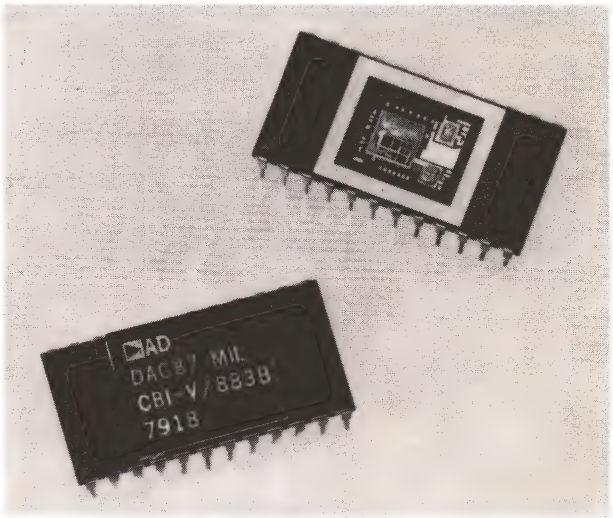


A modified 15-in.-diagonal Sony color TV that provides three switch-selectable modes—RGB, composite video and standard color TV—this low-cost monitor combines both versatility and a quality image.

In the RGB mode, the set accepts separate 0 to 1V dc inputs for its red, blue and green guns; this mode provides the highest possible resolution. The composite-video mode lets you input a standard composite-video signal and get a full-color picture on the screen. The third mode operates like a standard color TV, except for the addition of a composite-video output for driving remote monitors. $1195.

Matrox Electronic Systems Ltd, 5800 Andover Ave, Montreal, Que H4T 1H4 Canada. Phone (514) 735-1182. Booth No 1132. **Circle No 354**

HYBRID 12-BIT DAC

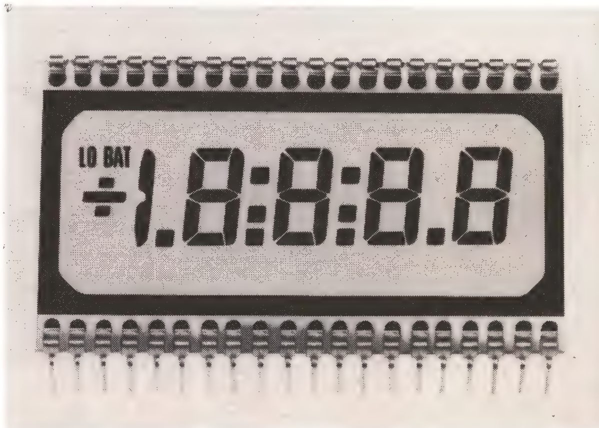


Second-sourcing the Burr-Brown DAC87 but incorporating three chips instead of 25, the AD DAC87 fits into any circuit using the B-B DAC87 and its internal gain resistors. It also works with the B-B trim circuit. Specs include maximum nonlinearity of ±0.012%, ±25-ppm/°C drift and power-supply sensitivity of ±0.003% FS/% V_S max.

This device incorporates a fully differential, nonsaturating precision current-switching cell structure; reliability is claimed to be five times better than that of its competition. DAC87-CBI-V/883, $109 (100).

Analog Devices Inc, Box 280, Norwood, MA 02062. Phone (617) 329-4700. Booth Nos 1133-35. **Circle No 355**

LIQUID-CRYSTAL DISPLAY



Measuring 2×1.2 in. overall, the 4½-digit Model FE0206 comes in transmissive, reflective or transflective modes and with −10 to +55°C or −5 to +80°C materials; you can specify either DIP-pin or pinless connections.

In addition to the 0.4-in. digits, the display contains four decimal points, a LO-BATT annunciator, plus and minus signs and two colons. Red, blue or green readouts are available on special order. $10.96 (100).

AND, 770 Airport Blvd, Burlingame, CA 94010. Phone (415) 347-9916. Booth No 1428. **Circle No 356**

New, high capacitance Q/PAC* power distribution elements are the exciting, revolutionary way to eliminate decoupling capacitors from printed circuit boards. Rugged Q/PAC elements are easy to install and increase system reliability through reduced part count.

Q/PAC elements are available in capacitance values up to 0.05µf per inch in lengths up to 16 inches. Configurations allow for either vertical mounting or horizontal installation under DIP packages.

*Patent Applied For

Q/PAC elements eliminate the need for on board power traces and extra board layers. They maximize packaging density and minimize signal interconnection problems.

Q/PAC elements feature a low dissipation factor, low inductance and low impedance.

Pack more on static and dynamic MOS memory boards, more on critical random logic boards.

Contact the Q/PAC Product Specialist at (602) 963-4584.

ROGERS

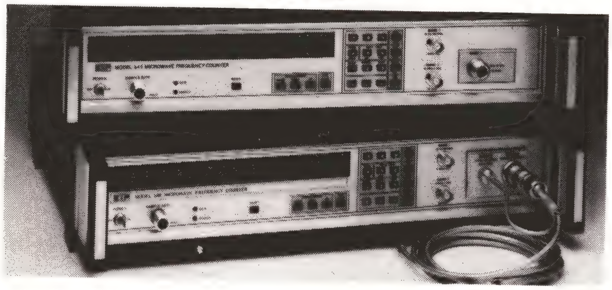
Rogers Corporation
Chandler, Arizona 85224

EUROPE: Mektron NV, Gent, Belgium JAPAN: Nippon Mektron, Tokyo

For more information, Circle No 73

Wescon/79 Products

MICROWAVE COUNTER



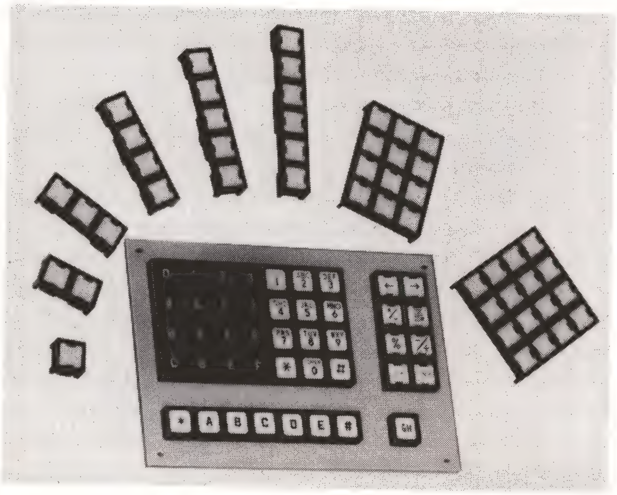
Model 548 furnishes frequency coverage from 10 Hz to 26.5 GHz, but this range can be extended to 40 GHz by installing Option 6 and adding a Model 591 remote sensor.

Coupling heterodyne conversion with μP technology, this counter provides sensitivity to −30 dBm, input protection to +37 dBm (5W), easy keyboard control and keyboard-selectable testing and diagnostics. Frequency-offset and frequency-limit capability come standard.

Options include power measurement, GPIB bus (IEEE-488), remote-programming/BCD output and DAC output. $5700. Delivery, 10 to 12 wks ARO.

EIP Microwave, 3230 Scott Blvd, Santa Clara, CA 95051. Phone (408) 244-7975. Booth No 1560. **Circle No 357**

MODULAR KEYBOARD SYSTEM



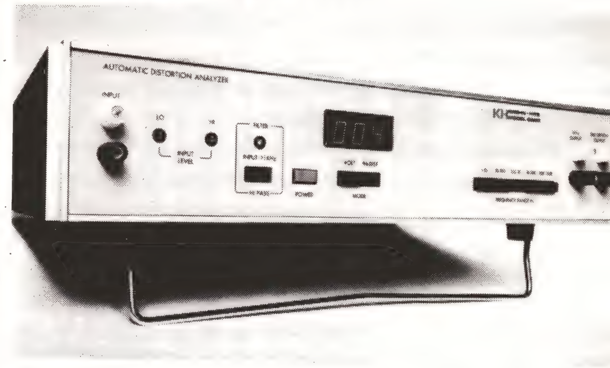
Users can readily create prototypes of nonstandard keyboard arrangements using System 87 modules. Any desired configuration is possible because ½-in. button centers are maintained when modules are stacked side by side.

The system includes single rows of one through six switches and 3×4 and 4×4 keyboard pads. Circuitry in the single-row switches is single pole/common bus, easily arranged into row and column switching when stacked. The 3×4 and 4×4 pads come with either matrix coding or single-pole/common-bus circuitry.

Modules mount readily on a pc board for prototype or short-run production, and a snap-on cap permits easy self legending (hot-stamped or molded-in legends are furnished for high-volume runs). A snap-dome switch contact with 3,000,000-cycle life comes standard. Keys stand only 0.35 in. above the pc board. $0.35 to $0.70 per button (1000).

Grayhill Inc, 561 Hillgrove Ave, La Grange, IL 60525. Phone (312) 354-1040. Booth Nos 1704-1712. **Circle No 358**

DISTORTION ANALYZER



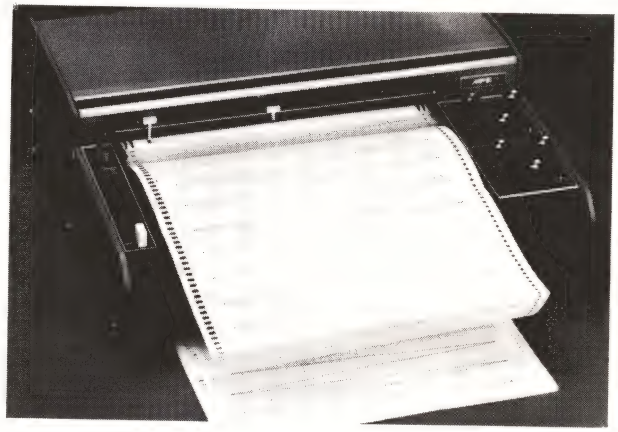
Over the 1-Hz to 110-kHz range, Model 6800 makes automatic distortion measurements in less than 10 sec. Distortion resolution reaches 0.001%, permitting measurements down to 0.003%.

Auto level-set capability handles any input between 1 and 130V rms; frequency-range selectors automatically null fundamental frequency over a 10:1 range, and the 3½-digit display autoranges, taking much of the work out of making a measurement.

Additionally, a self-contained, 5V-rms 1-kHz sine-wave source with less than 0.003% distortion serves for excitation, a switchable 1-kHz high-pass filter cuts low-frequency noise, and a distortion output permits further analysis. $1500.

Krohn-Hite Corp, Avon Industrial Park, Bodwell St, Avon, MA 02322. Phone (617) 580-1660. Booth No 1349. **Circle No 359**

POTENTIOMETRIC RECORDERS



Accepting both Z-fold and roll paper, flatbed units in the 2100 Series come in both lab and dedicated versions.

Lab versions provide 13 switchable calibrated spans (1 mV to 10V FS) and 10 pushbutton-selected chart speeds (1 in./hr to 20 in./min, or 2 cm/hr to 40 cm/min); operating power comes from 110 to 120V or 220 to 240V±10%, 50 to 400 Hz. Dedicated versions have a 1V span and chart speed of 6 in./min.

For all units, specs show 0.5 sec for full-scale excursion, accuracy of ±0.2% FS and linearity of ±0.1% FS. Power consumption does not exceed 40W for a single-pen version or 60W for a 2-pen unit. $595 (OEM) to $1295 (2-channel lab).

MFE Corp, Keewaydin Dr, Salem, NH 03079. Phone (603) 893-1921. Booth Nos 1847-49. **Circle No 360**

UDS has the first 4800 bps Bell-compatible OEM modem– <100 square inches

UDS has leapfrogged current LSI technology with nanosecond microprocessor performance! All components are industry standards — no custom or single source parts are used.

- **First chance to build-in.** Radically reduced space requirement (including .5" maximum component height) and low power consumption ease design constraints.
- **Design flexibility.** Most parameter changes require firmware alterations only. Physical layout can be adapted to your specifications.
- **Adaptive equalization.** Innovative design accommodates diverse line conditions.
- **Bell compatibility.** Available in 208A (four-wire) and 208B (two-wire) configuration.
- **Cost/effectiveness.** Microprocessor power makes the integral UDS 208 your most cost-effective buy for OEM applications at 4800 bps.

For further details on the UDS 208 or our lower speed modems (103s, 201s, 12 • 12s etc.) contact Universal Data Systems, 4900 Bradford Drive, Huntsville, AL 35805. Phone 205/837-8100; TWX 810-726-2100.

IDCMA

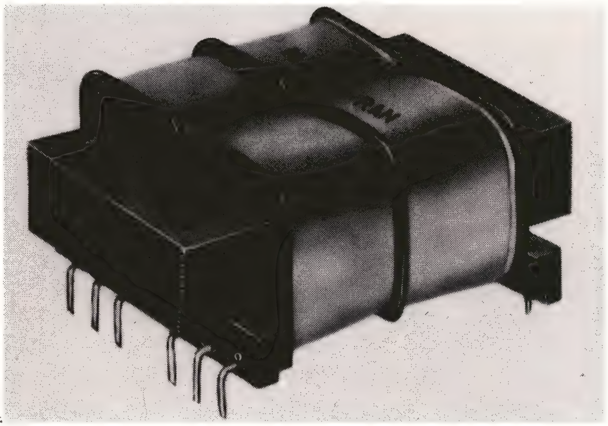
universal data systems

Confidence in Communications

For more information, Circle No 54

Wescon / 79 Products

PC-BOARD TRANSFORMER

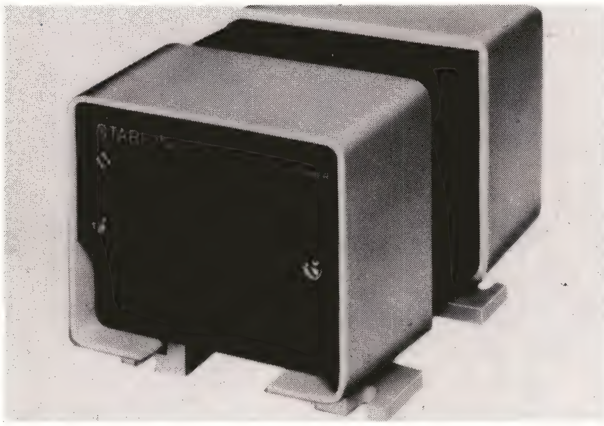


Extending only 1.065 in. above a board and equipped with pins designed for 1½-in. card spacing, the FlatStack PFT12-35 suits logic/op-amp, μP and industrial-control applications. It's rated at 12 VA, has a 115/230V, 50- or 60-Hz primary and delivers output voltages that permit regulated dc outputs of 5V at 300 mA and ±15V at 85 mA.

Hum-bucking semitoroidal construction permits balanced windings and reduces the external field, while a split bobbin improves isolation. All connections terminate in pc pins, permitting primary-voltage changeover through the pc board. $11.60.

Microtran, Box 236, Valley Stream, NY 11582. Phone (516) 561-6050. Booth No 1333. **Circle No 361**

ISOLATION TRANSFORMERS



Various models of Stabiline IT isolation transformers protect μPs, medical equipment, computers, industrial controls, communications equipment, processors and other sensitive loads from electrical noise on power lines. Ranging in power rating from 0.5 to 5 kVA, they offer 1000-MΩ insulation resistance, 2500V-rms dielectric (primary to secondary), 0.005-pF maximum interwinding capacitance and 126 dB of common-mode attenuation.

You can wire each unit for 120 or 240V-ac input or output (input is 50 or 60 Hz, single phase). Operating ambient can be up to 40°C, and the unit's temperature rise equals 90°C. Regulation specs at 4%. $208 to $437.

Superior Electric Co, Bristol, CT 06010. Phone (203) 582-9561. Booths No 618-622. **Circle No 362**

PROGRAMMABLE FILTER

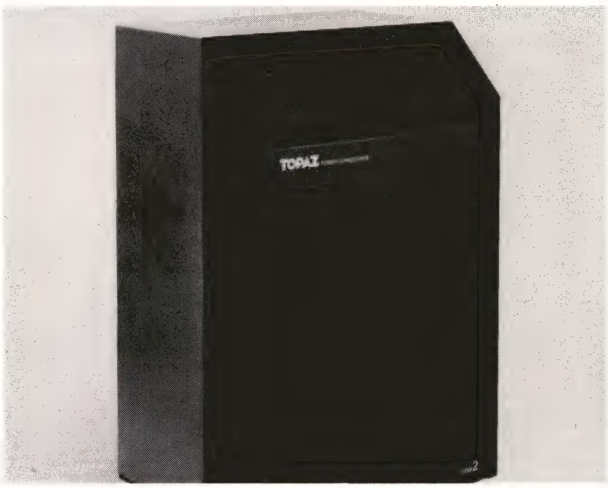
Suitable for implementing extremely precise measurements of narrow-band noise or modulation index—or for determining individual-channel signal level in crowded communication spectra—Model 751A Brickwall filter provides a 115-dB/octave roll-off on both sides of the passband.

Basically, it's a seventh-order elliptic (Cauer) filter with 0.3-dB p-p passband ripple and 85-dB stopband attenuation above 1.7× cutoff frequency (low pass) and below 0.6× cutoff frequency (high pass).

You can independently program the filter's LF and HF cutoffs, setting both center frequency and bandwidth anywhere in the 1-Hz to 100-kHz band. Options include remote digital programming of high and low cutoff frequencies, as well as prefilter and postfilter gains, using a built-in BCD parallel-input buffered interface (IEEE-488 is also available). $3300.

Rockland Systems Corp, Rockleigh Industrial Park, Rockleigh, NJ 07647. Phone (201) 767-7900. Booth No 1259, 60. **Circle No 363**

POWER CONDITIONERS



Single-phase Line 2 conditioners come with 5-, 7.5- and 10-kVA power ratings and operate from 208, 220 or 240V (tap selectable), 47 to 63 Hz. Each unit delivers 117, 220 or 234V output, regulated within ±7%.

Aimed at applications in which they protect minicomputers from power-line noise and voltage fluctuations, these units operate at 94% efficiency, have less than 0.001-pF coupling capacitance, provide more than 140 dB of common-mode rejection and add less than 0.1% of harmonic distortion. They respond in less than 1 cycle and are spec'd for 0 to 40°C operating temperatures.

Load power factor, current wave shape and turn-on surges have virtually no effect on Line 2 units' operation, and their low output impedance is particularly valuable. $1700 to $2690.

Topaz Electronics, 3855 Ruffin Rd, San Diego, CA 92123. Phone (714) 279-0111. Booth Nos 1832-34. **Circle No 365**

A lot of complex thinking goes into the Teletype* model 40 printer. And, incredibly, it all fits on this 9″ by 19″ circuit card.

More brains; less brawn.

That's the advantage of an electronic printer like our 300 LPM model 40 series. The LSI (Large Scale Integration) circuitry tucked underneath the printer can perform functions with greater reliability than mechanical hardware.

And it can perform them in a fraction of the time with a fraction of the parts. Plus, fewer moving parts means less maintenance and increased printer life.

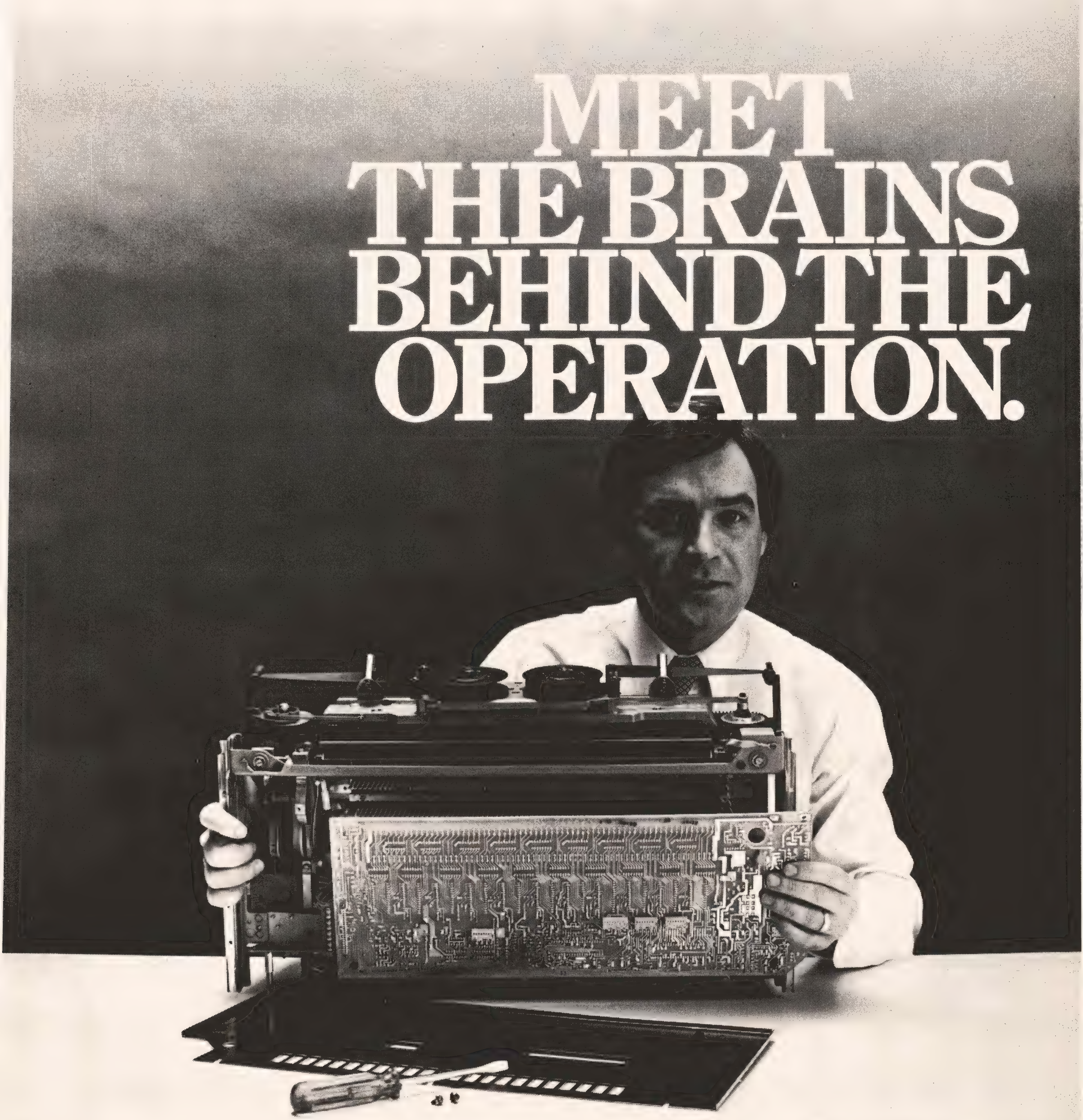
All you have to do is plug it in.

Just attach the AC power and a serial signal source and your model 40 is ready to go to work. There are 32 switch-selectable options and self-diagnostics available at no additional cost. Housed in an attractive cabinet, if you need one. And our technical assistance is never extra.

So for not much money, the brains behind our operation can become the brains behind yours.

Teletype Corporation
5555 Touhy Avenue, Dept. 3185, Skokie, IL 60076.
Telephone (312) 982-2000.

For more information, Circle No 74

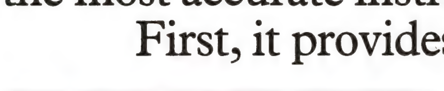


*Teletype is a trademark and service mark of the Teletype Corporation.

People who spend less for RLC testers get less. Unfortunately, so do people who spend more.

The fact is, the model 1657 Digibridge™, for just $1250*, is the most accurate instrument you can buy for anywhere near its price.

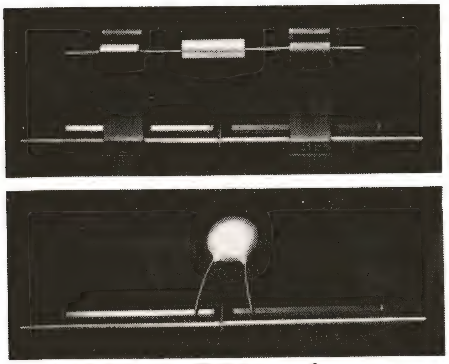
First, it provides the exceptional resolution of a 5-digit LED display for component value, and a 4-digit display for component quality. Even the more expensive instruments offer only 4-digit and 3-digit resolution. (The cheaper models don't



Both the RLC display and the DQ display (not shown) have an extra digit for better resolution.

even give you the second display.)

Also, the 1657 Digibridge features self-calibration, which no other instrument within a thousand dollars can offer. It contains a microprocessor that automatically adjusts the reading each time you use the tester. So your measurement is always accurate, to within ±0.2% — compared to ±0.25% on lower and higher priced instruments.

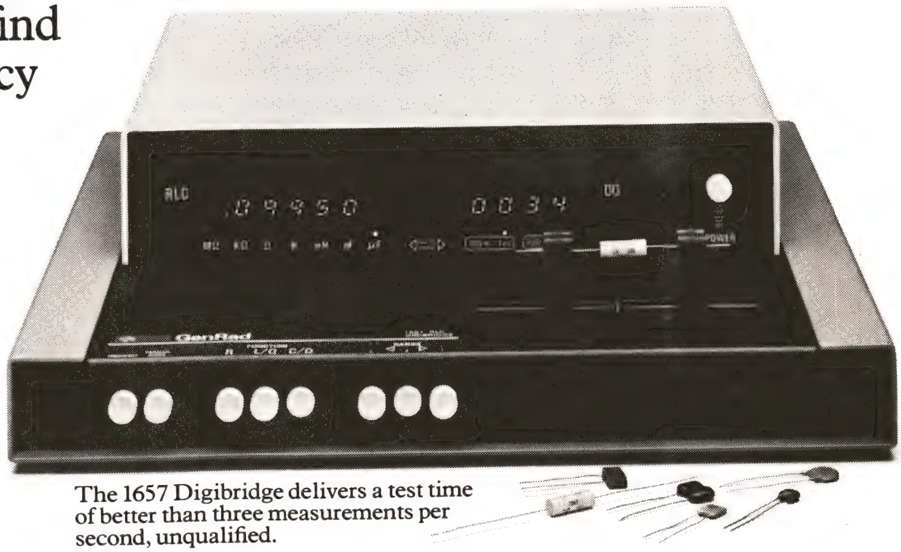

GenRad's built-in Kelvin test fixture can be used with axial leads, or with radial leads just by removing the clips.

And you can apply the Digibridge accuracy to most commonly tested components. Because you can perform C/D, L/Q, and R measurements at two test frequencies (1KHz and 100 or 120Hz), in series or parallel mode. Over a broader measurement range than most competitive testers.

The 1657 Digibridge is designed for convenience too, with push-button controls and automatic ranging provided by the microprocessor. Lighted arrows on the front panel tell you which range button to push, so no guesswork is required. And the built-in test fixture — standard on the Digibridge — makes it simple to insert both radial and axial lead components.

The model 1657 Digibridge, part of a family of precision RLC testers from GenRad. To find out just how much accuracy your money can buy, call toll-free 800-225-7335 (in Mass. 617-779-2825).

Or write GenRad, Concord, MA 01742.



The 1657 Digibridge delivers a test time of better than three measurements per second, unqualified.

*U.S. Price

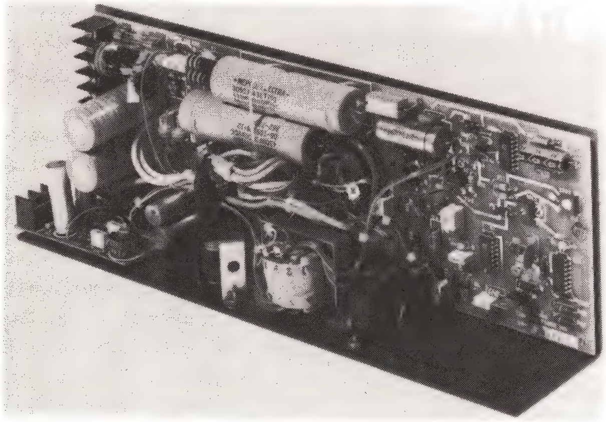
GenRad

Put our leadership to the test.

For more information, Circle No 75

Wescon / 79 Products

MULTIOUTPUT SWITCHERS

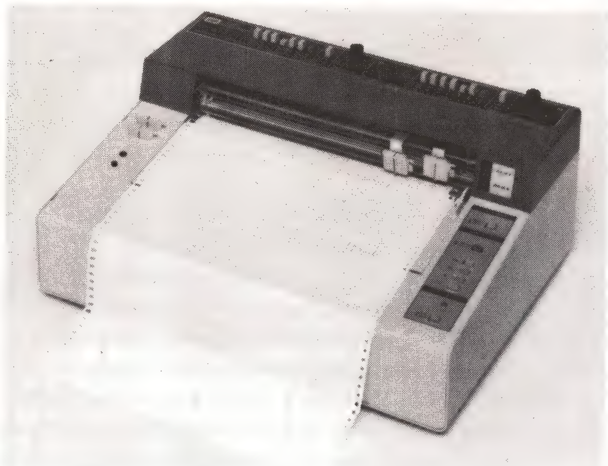


Units in the SWS250 Series provide various output combinations of 5, 12 and 15V, such as 5/12/12V, 5/5/12/12V, 5/15/15V or 5/5/15/15V. All versions offer soft start, OVP, low-input shutdown, low EMI/RFI (suppressed at the source by line filters), paralleling capability and 30-msec holdup after line dropout. They also feature remote-sense and remote-shutdown capabilities.

Each switcher weighs 4.5 lb, measures 3×4.9×15 in. and is designed to meet UL 478. From $310.

Standard Power Inc, 1400 S Village Way, Santa Ana, CA 92705. Phone (714) 558-8512. Booth No 1527. **Circle No 364**

FLATBED OEM RECORDER

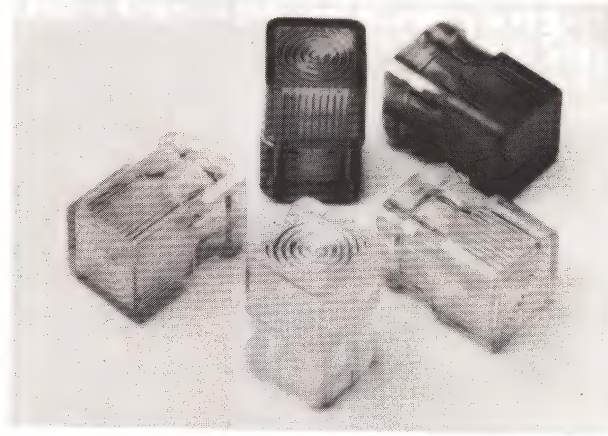


Joining the many lab-type recorders produced by its manufacturer, Type 3021 uses an automatic null-balancing dc servo mechanism and provides one or two channels of ink writing using felt-tip pen cartridges.

Basic accuracy specs at ±0.25% of the 250-mm effective recording span. The recorder accepts 270mm×15m Z-fold paper or 270mm×20m roll chart, operating at speeds of 2, 6, 20 or 60 cm/min or cm/hr. Voltage ranges span 10 mV to 50V FS in 1-2-5 sequence. Power required (must be specified) can be 100, 120, 200, 220 or 240V, 50 or 60 Hz. Less than $1000 for single-pen version.

Yokogawa Corp of America, 5 Westchester Plaza, Elmsford, NY 10523. Phone (914) 592-6767. Booth Nos 1749, 51. **Circle No 366**

LED MOUNTING CLIPS



Because of their construction, which features molded Fresnel rings and striated lines on the viewing surface, Series 1933 square-lens clips for T-1¾ LED lamps provide even illumination. Their cellulose-acetate-butyrate bodies are available in amber, clear, green, red or yellow.

Mounting is a snap, either singly into ¼-in.-square punched holes on ⅜-in. centers, or ganged in a ¼-in.-wide slotted hole. $0.20 (500).

Industrial Electronic Engineers Inc, 7740 Lemona Ave, Van Nuys, CA 91405. Phone (213) 787-0311. Booth Nos 1203, 05, 07. **Circle No 368**

SCOPE CALIBRATOR

Providing calibrated amplitude signals, precision timing and fast-rise pulses for determining response bandwidth, the TE303 allows thorough checking of scope performance.

The unit's 1-kHz trapezoidal waveform lets you check trigger-level performance, while its 1-kHz square-wave output (2-nsec rise time) lets you set up undershoot and overshoot characteristics of both the internal and external amplifiers and the attenuators. Waveform amplitudes adjust from 0.1 mV/div to 50V/div in 1-2-5 sequence; switching adjusts for graticule heights of 6, 8 and 10 divisions.

For time-base calibration, crystal control holds the frequency within 0.01%. Timing marks are positive-going 1V pulses, adjustable from 100 nsec to 0.5 sec in 1-2-5 sequence. $935.

Zi-Tech Div Alkenwood Corp, Box 26, Palo Alto, CA 94302. Phone (415) 326-2151. Booth No 1161. **Circle No 367**

Single or dual track, MFE is the driving force in cassette transports.

We revolutionized the digital cassette industry by making the first simple, reliable tape drive.

Now we offer that reliability in a full line of transports, both single and dual track.

The Single-Track 250B. With just two moving parts (no mechanical adjustment, ever) the 250B offers a record of performance no competitor can match: an MTBF of 15,000 hours. The 250B also has the widest ANSI/ECMA-compatible read/write speed range on the market (5-40 ips) and data transfer rates up to 32K bps.

The Dual-Track 450B. This new model gives you up to 720,000 formatted character storage, and features the exclusive TACHLOK™ servo speed control—for constant tape speed. Like the 250B, the 450B has data transfer rates up to 32K bps and needs no mechanical adjustment. Both models are available with a variety of interface options.

The Single-Track 250BH—for hostile environments. This incredibly rugged version of the 250B can handle just about any condition. Operating temperatures from −40°C to +70°C, for example. And all kinds of shock and vibration. The 250BH has been field proven in some of the toughest applications you can name. Indoors and out. In a wide range of industries.

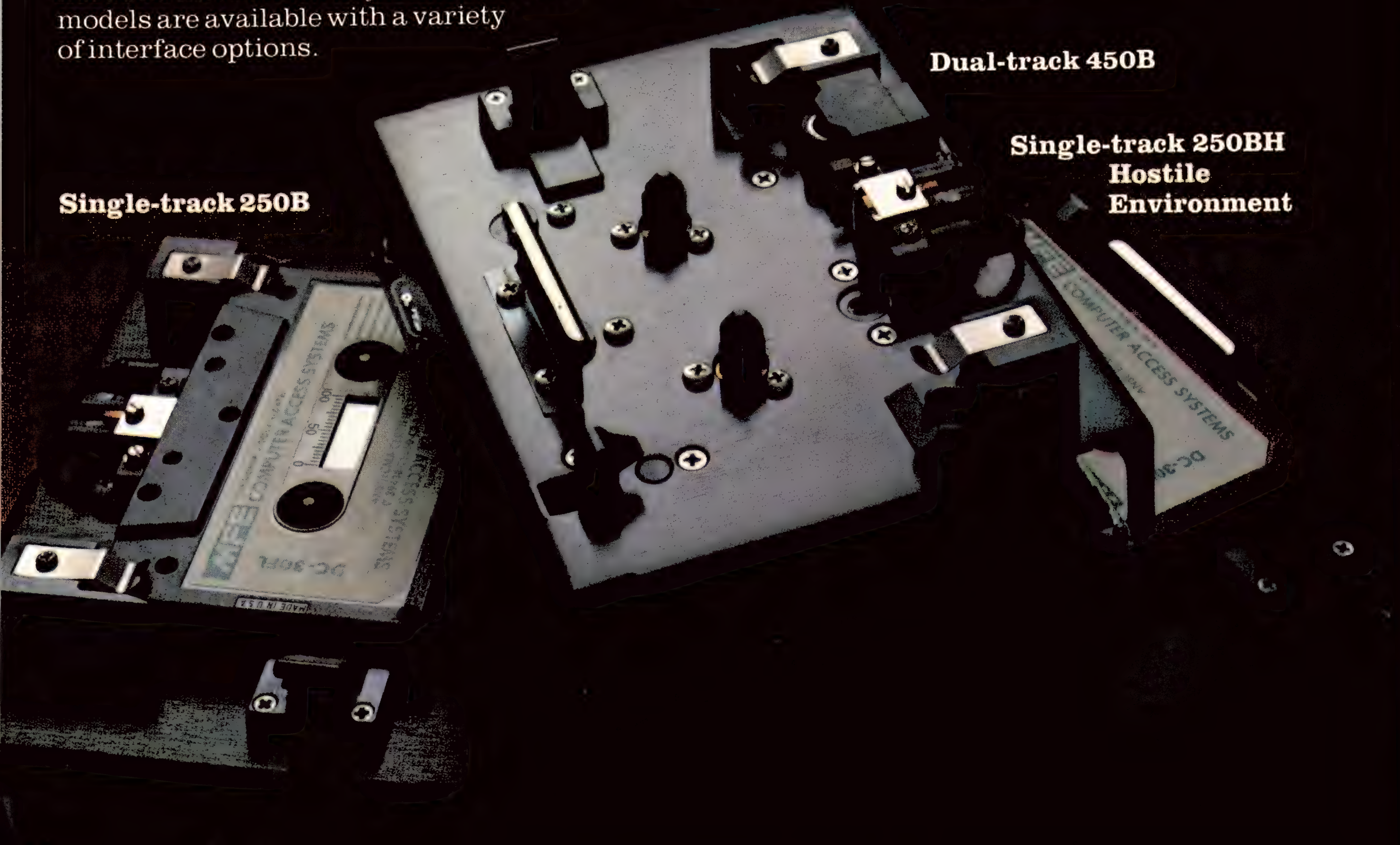
All three models are available in volume, ready to ship. And we can customize to meet your exact design requirements.

Call toll free 800-258-3884. MFE Corp., Salem, N.H. 03079.

In Europe: MFE Limited, West Lothian, Scotland, Tel. (0589) 410 242. MFE Products Sa, Vevey, Switzerland. Tel. 021 52, 80, 40. (MFE has complete worldwide representation. Contact us for the rep nearest you.)

MFE

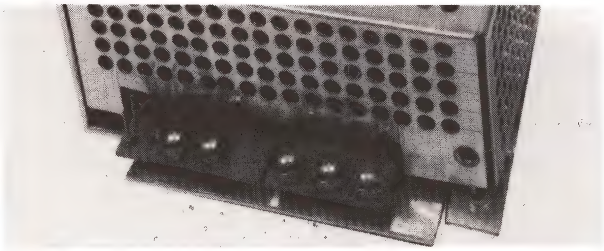
™MFE Corporation



For more information, Circle No 76

Wescon/79 Products

50W SWITCHERS



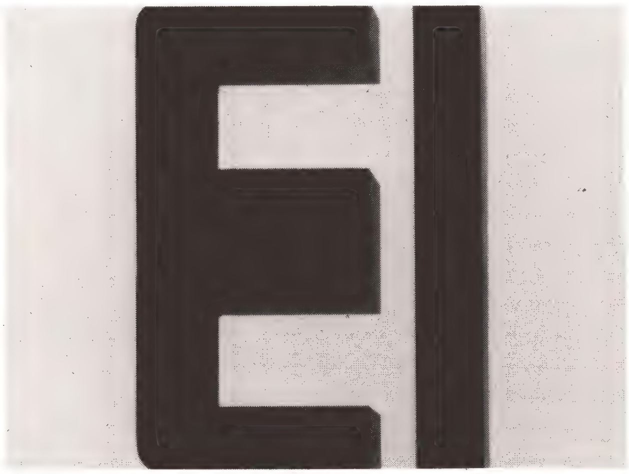
ES-E Series power supplies challenge their linear competitors with very low price tags; for example, the 5V/10A model costs only $89 in unit quantities. Yet their manufacturer hasn't sacrificed reliability to achieve this economy: MTBF exceeds 50,000 hrs, and all models carry a 2-yr warranty.

Two factors contribute to the units' low price and high performance: a sophisticated computer-aided design technique that guarantees circuit integrity by using worst-case-analysis criteria, and a proprietary single-chip controller. The latter contains a pulse-width modulator, a soft-start circuit, current-limit protection, a stable frequency oscillator, a deadband network, regulated voltage references, precision comparators and control logic. It reduces the supplies' parts count by over 20%, compared with older discrete-component designs.

Externally, ES-E supplies measure only 2×5×4 in., permitting mounting in tight spaces. Electrical specifications include greater than 70% efficiency, 50-mV p-p maximum noise and ripple, ±0.1%+1-mV load and line regulation and 16-msec hold-up time (32 msec optional). Special control circuits eliminate turn-on and turn-off spikes.

Power/Mate Corp, 514 S River St, Hackensack, NJ 07601. Phone (201) 343-6294. Booth Nos 1648, 50. **Circle No 335**

FERRITE CORES



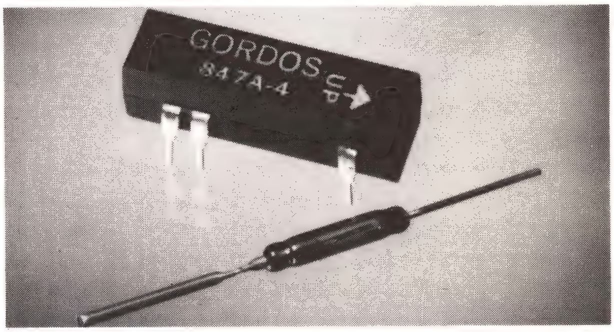
Ceramag 24B cores reduce losses by 30% at 16 kHz and 25% at 60 kHz, compared with designs using other materials. And these reduced losses are achieved with no changes in permeability or saturation level. Minimum losses occur between 85 and 95°C.

The cores come in standard IEC configurations. For example, E-type units can be specified in 28 sizes ranging from 17 to 103 mm, while EC types with round center legs are available in 35-, 41-, 52- and 70-mm widths. Custom designs can also be supplied.

Price depends on size and style; a typical 35-mm E core (Model 50-0660) and I bar (Model 57-1811) combination costs $0.38 (1000).

Stackpole Carbon Co, Electronic Components Div, St Mary's, PA 15857. Phone (814) 781-1234. Booth Nos 1413, 15. **Circle No 336**

MERCURY-WETTED REED RELAY



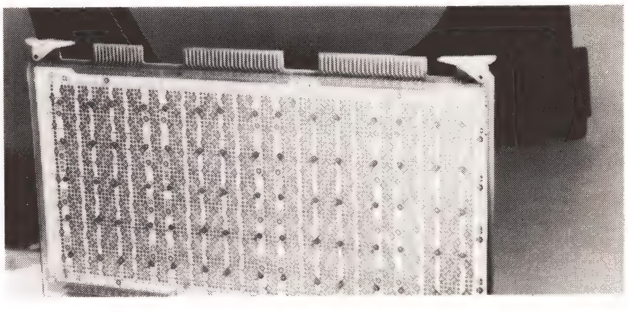
Noteworthy because it's small, fast and sensitive, this device can be ordered as a reed-switch capsule or a complete relay. In either case, life expectancy runs to billions of cycles.

In capsule form (Model WR-1125), the device measures 0.5 in. long and 0.1 in. in diameter. Operating frequency specs at 200 Hz max, while typical functioning times run 1.8 msec for operating and 0.9 msec for release. Sensitivity ranges from 25 to 60 ampere-turns.

As you'd expect, the capsule must be mounted within ±30° of vertical for proper operation. All devices are tested at 15 Hz and 50% overdrive. Power rating (ref) equals 30W. $1.73 (500).

Gordos Corp, 250 Glenwood Ave, Bloomfield, NJ 07003. Phone (201) 743-6800. Booth No 827. **Circle No 376**

WIRE-WRAPPING BOARD



Model EECO-80-10 allows designers to build custom subsystems for equipment that uses the Intel SBC-604/614 modular card cage. This universal 2-level wire-wrapping board accepts up to 132 16-pin IC sockets or an equivalent mix of devices with 0.2- to 0.9-in. centers.

Constructed from 0.062-in. NEMA-FR4 flame-retardant glass epoxy, the board features connectors and preinstalled I/O pins that are gold plated per MIL-G-45204. Its design minimizes noise problems by incorporating a continuous 2-oz copper-matrix ground plane; mounting holes for numerous power-supply decoupling capacitors are also provided.

A Lexan cover supplied with the $100 board protects pins from damage. Sockets and wire-wrapping/documentation services are available.

EECO Inc, 1601 E Chestnut Ave, Santa Ana, CA 92701. Phone (714) 835-6000. Booth Nos 1611-1617. **Circle No 338**

The MC² from Pyle gives you more design flexibility than any connector in history.

Until the development of the MC²™ (Modular Concept/Multi-Cell) connector system, you either had to design around existing connectors or buy expensive tooling for specialized applications. The former was a nuisance; the latter time-consuming and costly.

We solved the problem by developing a "family" of components consisting of 4 shell sizes and a series of insertable, contact-carrier modules available in a variety of removable, crimp-type contact sizes and arrangements. You simply insert the appropriate modules into the shells and you have, in effect, designed your own connector. And should you choose to interchange male and female components in the same shell, you can do that, too.

<u>The MC² provides you with the capability to design any of 36,936 different connectors.</u>

But, all connectors are not created circular.

The MC² concept can be applied to whatever shape suits your particular purpose. If you will simply tell us what you need to solve your system-component interconnect problems, we'll come up with the economical answer.

And you and we together will continue to advance the state of the art through design innovation.

Write us for our MC² catalogue now;

For more information, Circle No 78

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Better connectors. By design.

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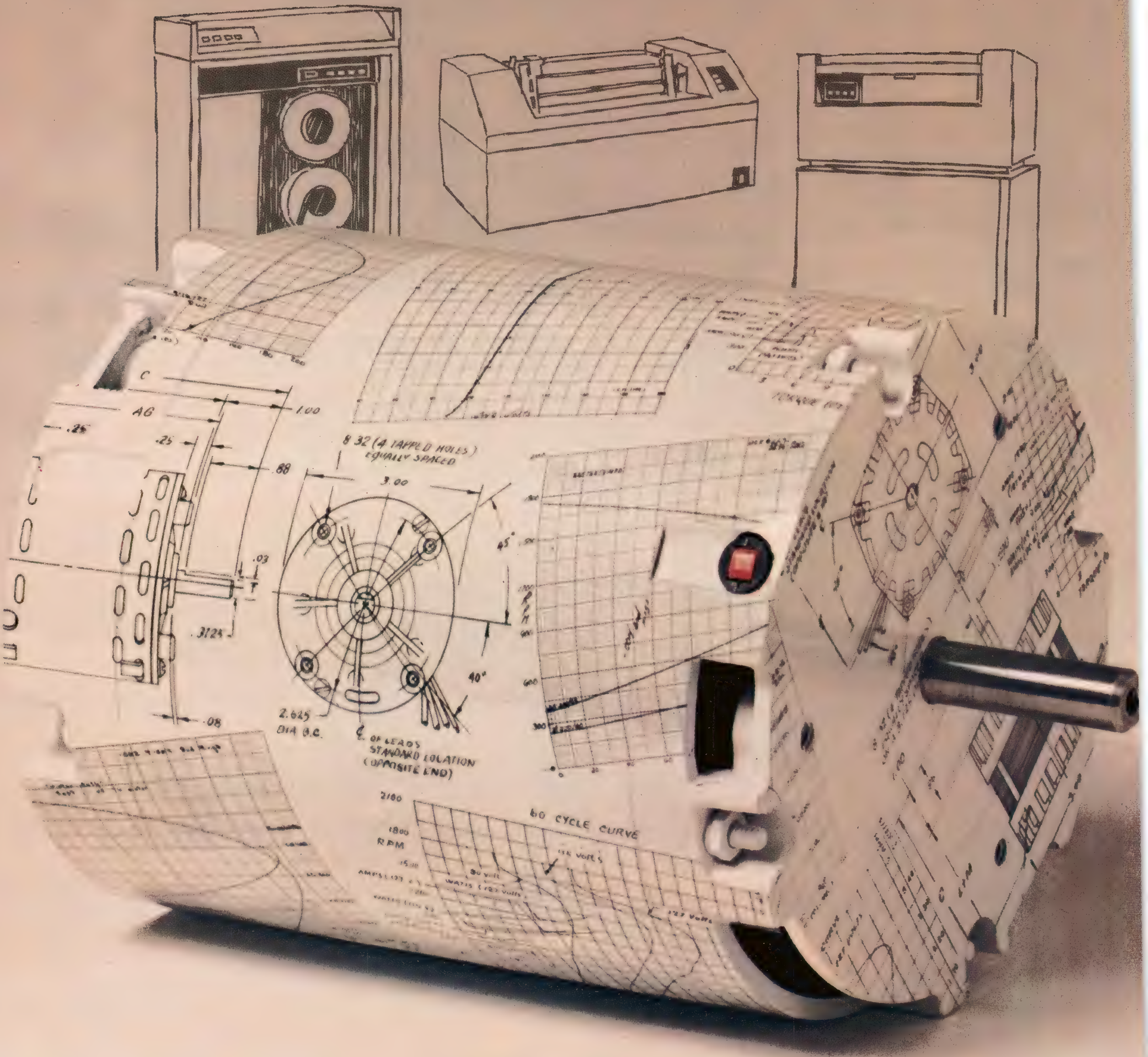
HOWARD® motor-makers do great things with your specs for induction drive motors..



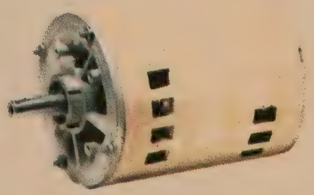
...and they price them very, very competitively

26 Frame Induction Motor

When you need an induction drive motor you want it designed exactly as you need it. Without hassles, without design headaches. That's the way Howard's motor-makers operate. They respond to your needs with fast action.

33 Frame Induction Motor

Tough and demanding customers such as IBM, Burroughs, Shugart, Documation (as well as scores of others) have found that Howard's engineering flexibility and adaptability makes it easy to get just exactly the induction drive motors they need.



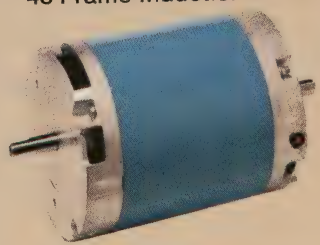
42 Frame Induction Motor

We're small enough to react positively to your development time-tables — big enough and experienced enough (over 11,300,000 motors in the past 10 years) to deliver quality motors at a very competitive price.

Check with Howard's motor-makers for any or all of your induction drive or motor parts sets needs. You'll discover that Howard's custom engineering approach makes your projects go smoother, faster — without paying premium prices.

48 Frame Induction Motor

WRITE TODAY for TWO NEW INDUCTION MOTOR CATALOGS that provide torque curves, ratings, dimensional drawings on the complete line of 26, 33, 42, 48 and 56 Frame induction drive motors and motor parts sets.



56 Frame Induction Motor

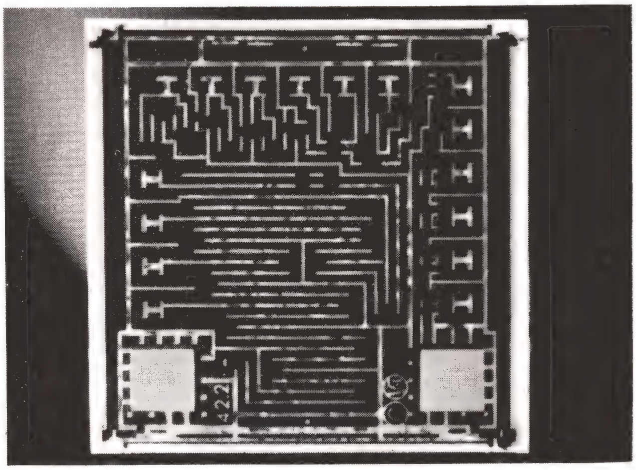
HOWARD® POWERED

HOWARD INDUSTRIES • One North Dixie Highway • Milford, Illinois 60953 • Phone: (815) 889-4105

For more information, Circle No 79

Wescon/79 Products

POWER RESISTORS

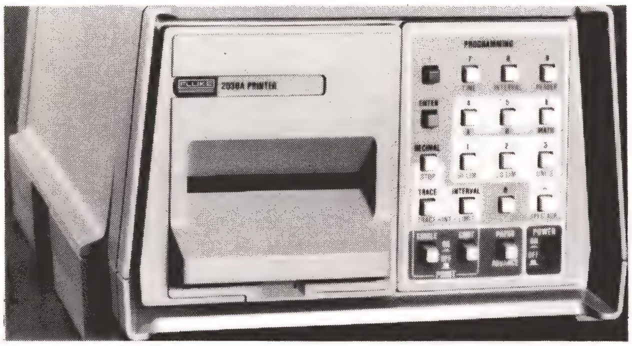


Capable of handling 3W continuous power at 125°C in free air, members of the precision power plate resistor (PPPR) family can dissipate 6W if mounted on an aluminum heat sink or 10W on a water-cooled copper heat sink. Resistance values from 10 to 5000Ω, with tolerances down to 0.005%, are available in a package measuring 1×1×0.025 in. Larger models, which include values down to 0.5Ω at 0.25% tolerance, have a higher continuous-power capability.

Stability over time and temperature is noteworthy. Higher resistance units spec load-life stability of 0.03% max ΔR under full rated power at 125°C for 2000 hrs; nominal thermal drift equals 2 ppm/°C over 0 to 40°C. (The low-value units exhibit still higher stabilities.) $30 to $50 (100), depending on resistance value. Delivery, stock to 12 wks ARO.

Vishay Resistive Systems Group, 63 Lincoln Hwy, Malvern, PA 19355. Phone (215) 644-1300. Booth No 73. **Circle No 337**

COMPUTING/CONTROLLING PRINTER

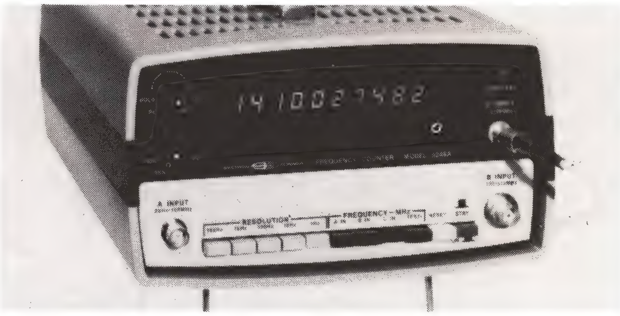


Features not previously available in most printers and plotters—such as crystal-controlled real-time storage to 100 hrs, time-interval printing from 1 sec to 100 hrs, data identification with a programmable 6-digit heading and math scaling functions—set Model 2030A apart. It provides 6-digit constants for scaling, programmable annotation that overrides measurement-instrument units with four alphanumeric symbols, alarm activation when data exceeds 6-digit limit setpoints and seven printing modes.

Portable, stackable and rackable, Model 2030A is housed in the new PTI (portable test instruments) package. It can scan several instruments and translate numeric data into a visible trace pattern—or apply limits and activate alarms. You can operate the instrument from an external 12V supply if necessary. $995. Delivery, 60 days ARO.

John Fluke Mfg Co Inc, Box 43210, Mountlake Terrace, WA 98043. Phone (206) 774-2211. Booth Nos 1141-47, 1242-48. **Circle No 378**

MICROWAVE FREQUENCY COUNTERS



Claimed the smallest and lightest bench/portable microwave counters currently available, Models 6246A and 6245A measure just 4.75×8.38×13.5 in. and weigh only 12 lbs. The 6246A accommodates signals from 20 Hz to 26 GHz; the 6245A, from 20 Hz to 18 GHz.

Both instruments handle input signal levels from −25 to +27 dBm. A proprietary measuring technique, combined with high adjacent-signal rejection and high-speed tracking capabilities, yields excellent AM and FM performance.

Other features include an overload-warning indicator, 10-digit LED display and optional IEEE-488 interface. Power consumption equals 35W. $4250 and $3750, for the 6246A and 6245A, respectively. Delivery, 60 days ARO.

Systron-Donner Corp, 935 Detroit Ave, Concord, CA 94518. Phone (415) 676-5000. Booth Nos 1653-1657. **Circle No 339**

GAUSSMETER

Model 904 measures magnetic flux in the range between 30G and 30 kG, achieving 3% FS accuracy. LED lamps adjacent to its analog meter indicate field polarity, and an analog output voltage corresponding to the flux density of either dc or ac fields is available at the rear panel.

Probes for the meter operate on the Hall-effect principle and come in a wide variety of axial, transverse-field and tangential models. Simple self-contained internal calibration avoids the need for a reference magnet. $365; probes approximately $175 each.

RFL Industries Inc, Boonton, NJ 07005. Phone (201) 334-3100. Booth Nos 1343, 45. **Circle No 372**

What makes GE thin edgewise instrument readings so accurate?

Alnico 8 power.

A high strength Alnico 8 magnet puts extra torque into every mechanism. This makes GE thin edgewise instruments less susceptible to reading errors caused by friction or static. They will continue to meet or exceed all applicable ANSI C39.1 specifications for years.

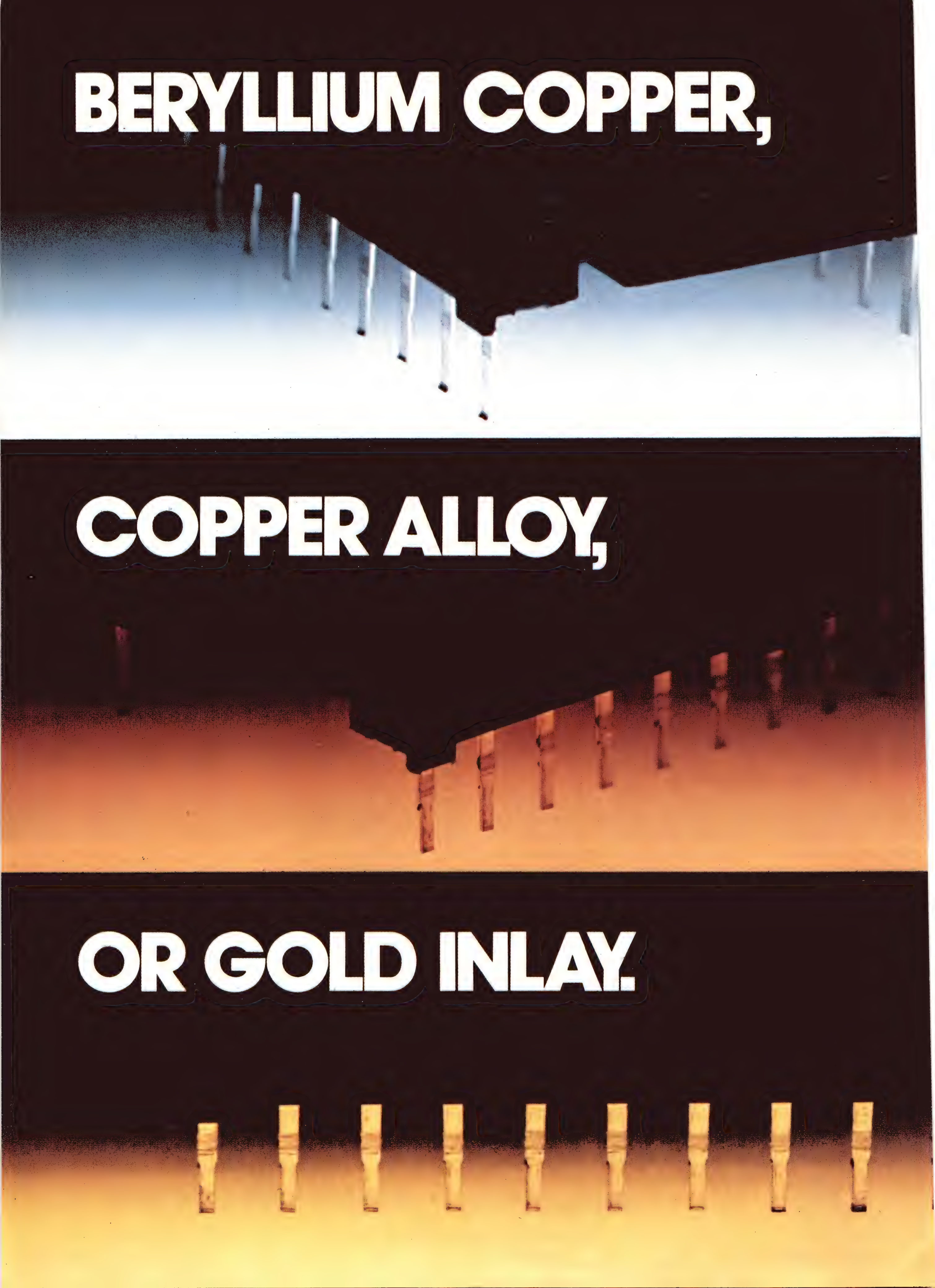
Available in both vertical and horizontal models, these compact instruments save valuable panel space in all three sizes— 1½, 2½, and 3½ inches. All are attractively housed in virtually unbreakable LEXAN® resin cases. General Electric thin edgewise instruments are interchangeable with most competitive models and are easily modified for special applications.

For full information on General Electric's complete line of ac and dc thin edgewise ammeters (from microamps up) and voltmeters (from millivolts up), write to Section 592-94, General Electric Co., Schenectady, NY 12345, or call your nearest GE sales office or distributor.

There's more to any GE instrument than meets the eye.

GENERAL ELECTRIC

For more information, Circle No 80


BERYLLIUM COPPER,
COPPER ALLOY,
OR GOLD INLAY.

NOW YOU GET AUGAT QUALITY, LOWER PRICES AND A CHOICE OF CONTACTS.

Which 200 Series socket best fits your application?

Beryllium Copper. The original 200 Series socket. It proved you don't have to sacrifice high performance for low cost. The 2xx-AG39D features beryllium

copper side-wipe contacts for maximum mechanical and gas-tight electrical performance. MIL-S-83734 approved.

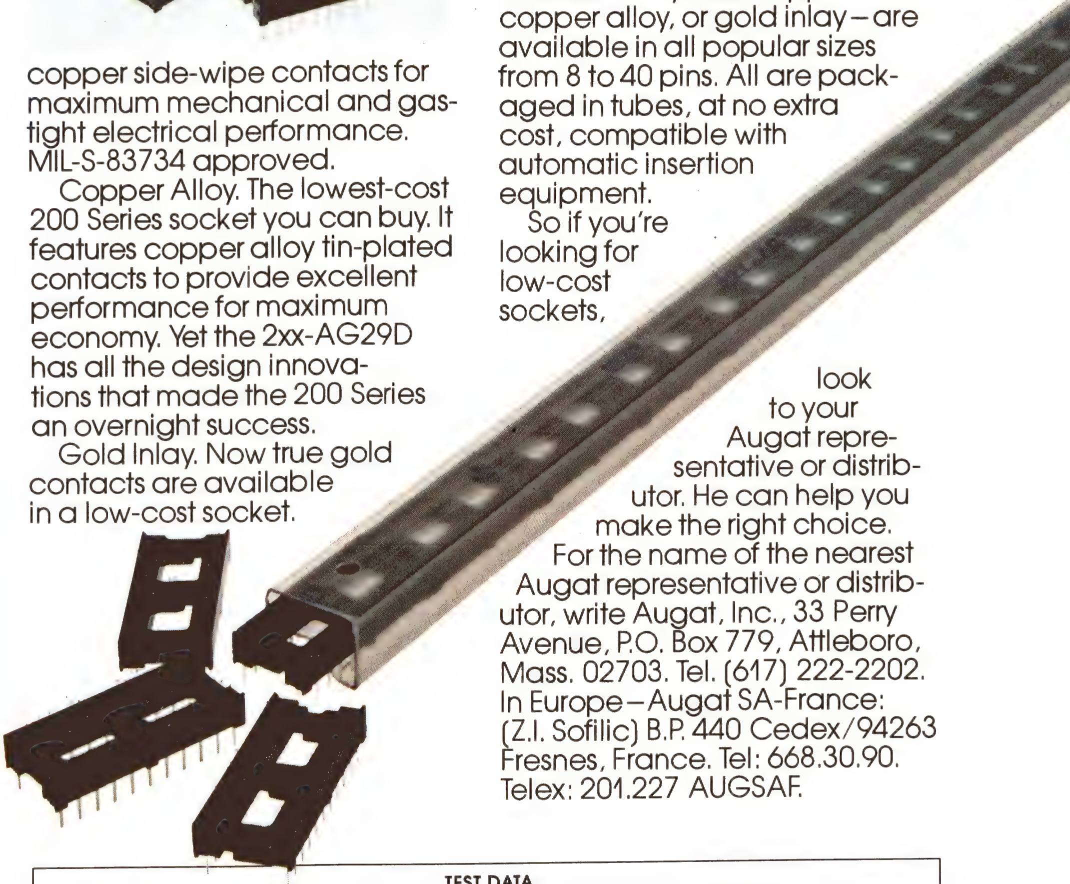
Copper Alloy. The lowest-cost 200 Series socket you can buy. It features copper alloy tin-plated contacts to provide excellent performance for maximum economy. Yet the 2xx-AG29D has all the design innovations that made the 200 Series an overnight success.

Gold Inlay. Now true gold contacts are available in a low-cost socket. Augat Series 2xx-AG49D sockets establish a new gold standard for dependability and economy.

And no matter which contact material you choose, you still get Augat's low-profile construction with end and side stackability to save valuable board space. Insulators with molded standoffs to provide clearance for proper cleaning. Closed bottoms to eliminate solder wicking. And all 200 Series sockets—beryllium copper, copper alloy, or gold inlay—are available in all popular sizes from 8 to 40 pins. All are packaged in tubes, at no extra cost, compatible with automatic insertion equipment.

So if you're looking for low-cost sockets, look to your Augat representative or distributor. He can help you make the right choice.

For the name of the nearest Augat representative or distributor, write Augat, Inc., 33 Perry Avenue, P.O. Box 779, Attleboro, Mass. 02703. Tel. (617) 222-2202. In Europe—Augat SA-France: (Z.I. Sofilic) B.P. 440 Cedex/94263 Fresnes, France. Tel: 668.30.90. Telex: 201.227 AUGSAF.



TEST DATA	
Insertion Force	230 grams when measured with a .015" x .023" rectangular lead.
Withdrawal Force	88 grams when measured with a .088" x .015" rectangular lead.
Initial Contact Resistance Per MIL-STD-1344, Method 3002	Low-signal level contact resistance at 20 mv open circuit measured at 6.79 milliohms, before corrosive atmosphere.
Socket Durability 50 Cycles with .014" x .021" Gauge	5.4 milliohms measured before durability and 6.15 milliohms after 50 cycles.
Corrosive Atmosphere per MIL-S-83734 Para. 4.7-16	No evidence of porous plating or exposure of base metal. Contact resistance averaged 6.64 milliohms indicating gas tight performance. Low-signal level 100 ma at 20 mv.

Your contacts are on the next page, too. Look for Augat's complete distribution listing.

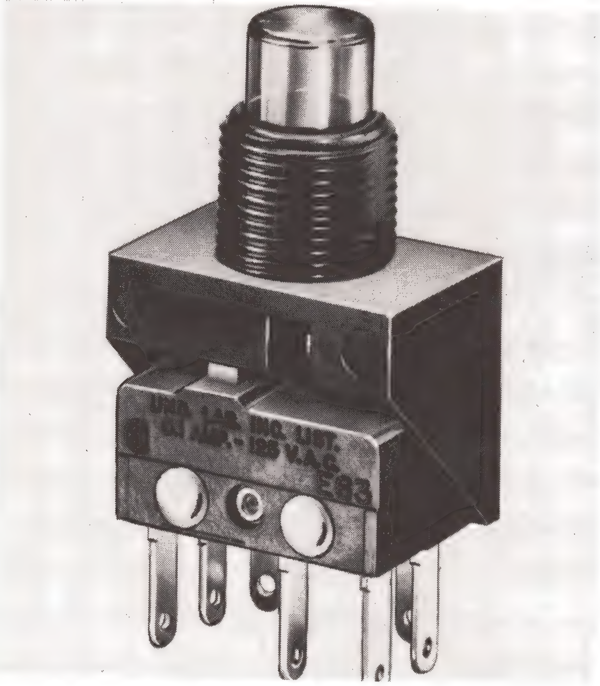
Send for detailed Augat test report #178

AUGAT®

Augat interconnection products, Isotronics microcircuit packaging, and Alco subminiature switches.

For more information, Circle No 81

LIGHTED PB SWITCHES



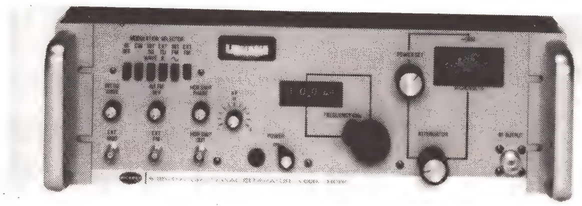
Series P1 lighted pushbutton switches handle power switching, low-energy switching or a combination of the two. Their elements feature a long-life, coil-spring snap-action mechanism and optional LED lighting.

Available in single- and double-pole designs, the units contain one or two of the company's subminiature switches. Of these, E62 Series devices are rated for 10.1A, 125 or 250V ac (¼ hp, 125V ac), while E63 Series units handle 100 mA, 125V ac for low-energy circuit applications. You can order dpdt versions with any desired mix of E62 and E63 switches.

The P1 switches also come in unlighted versions with black opaque or red translucent pushbuttons. Other button colors are available on special order. Terminal choices include 0.093-in. or 0.110-in. quick-connect, flat short-solder or flat pc-type pins. Single-pole, lighted, with E62 switch, $5.75; dpdt, $6.90.

Cherry Electrical Products Corp, 3600 Sunset Ave, Waukegan, IL 60085. Phone (312) 689-7700. Booth Nos 1534, 36, 38. **Circle No 377**

SIGNAL GENERATORS

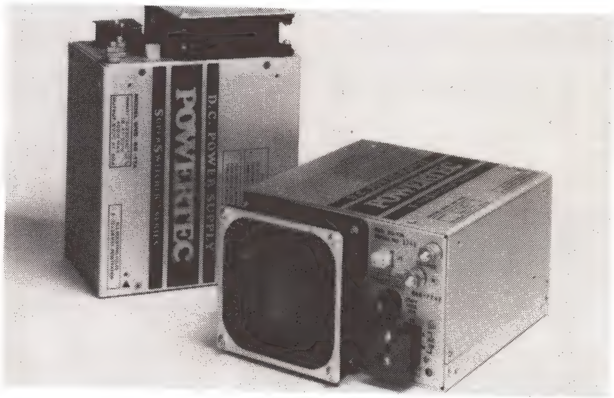


E Series modular microwave generators, solid-state except for their klystron oscillator, permit coverage from 3.7 to 12.4 GHz. Each of the four models provides widely adjustable FM and square-wave modulation of its accurately calibrated cw output. A horizontal-sweep output for the internal FM permits a convenient scope display of swept-band response plots; an optional internal isolator furnishes reverse-power protection during radar testing.

Features include digital readout of frequency to 0.5% accuracy, 130-dB calibrated output-level range and phase-lock capability. Model 1107E (3.7 to 8.4 GHz) and Model 1108E (6.95 to 11 GHz), $5150; Model 1108E-C (6.95 to 12.2 GHz), $5400; Model 1108E-CE (6.95 to 12.4 GHz), $5700.

Polarad Electronics Inc, 5 Delaware Dr, Lake Success, NY 11040. Phone (516) 328-1100. Booth No 1543. **Circle No 371**

SWITCHERS

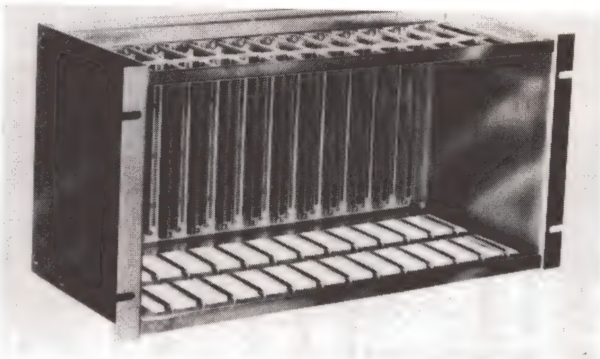


Ten models that deliver outputs ranging from 2V at 200A to 28V at 28A constitute the 9N Series of Super Switchers. Efficiency reaches 80%, and inputs (47 to 63 Hz) can be either 115/230V or 208V (single-phase) or 208V (3-phase). Input tolerance specs at +10, −20%, with no derating required at 50 Hz.

Standard regulation runs 4 mV for +10/−20% line change and 0.2% for 100% load change; ripple and noise typically equal 40 mV p-p or 7 mV rms. $450 to $695. Delivery, 14 wks ARO.

Powertec Inc, 20550 Nordhoff St, Chatsworth, CA 91311. Phone (213) 882-0004. Booth Nos 1228, 30, 32. **Circle No 374**

FAN-MOUNTING CARD CAGES



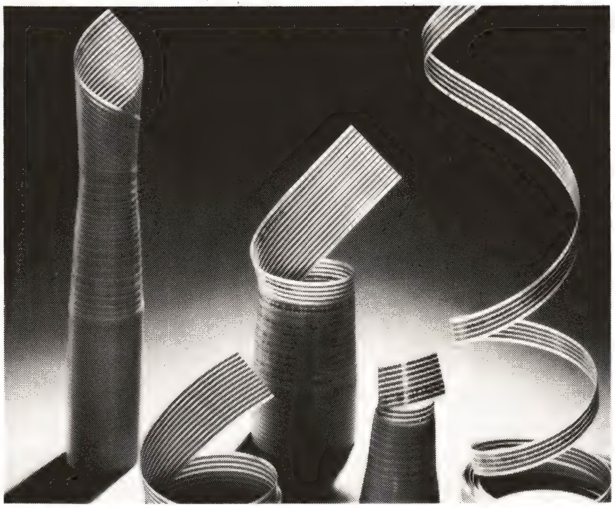
Fan-Cage units combine a standard 19-in. card cage with a fan container that increases the cage size by less than one RETMA unit. Fans are placed directly beneath the pc boards and/or power pack, creating an efficient, even air flow through the cage.

Provision for up to three 100-cfm fans (with mounting holes on 4⅛-in. centers) lets you cool even extremely hot boards. $44 (without fans).

Unitrack Div Calabro Plastics Inc, 8738 W Chester Pike, Upper Darby, PA 19082. Phone (215) 789-3820. Booth Nos 625-27; 524-26. **Circle No 373**

Wescon/79

FLEX FLAT-CONDUCTOR CABLE



Constructed with two to 35 0.003×0.062-in. conductors on 0.1-in. centerlines—but also available with nonstandard conductor widths and spacings—this cable sports a self-extinguishing dielectric rated at 300V dc and 5000-MΩ insulation resistance. Carrying capacity of the standard conductors equals 3A within the temperature range of −55 to +105°C.

Because of a proprietary manufacturing method, you can even order cables containing mixed conductor widths (0.032 to 3.962 in.) and spacings (0.032 to 3.898 in.). Maximum cable width must not exceed 4 in. From $0.005 to $0.03 per circuit foot.

AMP Inc, Harrisburg, PA 17105. Phone (717) 564-0100. Booth No 628. **Circle No 369**

IC REWORK STATIONS

Removing ICs the same way they are installed, Heat-a-dip rework stations incorporate two tiny solder pots that touch only the IC leads.

Using the furnished insertion and extraction tools, you can remove and replace an IC in seconds. Model 5002 Midi, a 50W unit, handles all ICs up to and including 0.4-in.-wide 24-pin versions, while Model 5003 Maxi covers all ICs with up to 40 pins and readily adapts to special heads for components such as connectors and relays. Model 5002, $295; Model 5003, $395—both complete with 14- to 16-pin head, extraction tool, insertion tool and head cleaner.

Micro Electronic Systems Inc, 159 Main St, Danbury, CT 06810. Phone (203) 797-1441. Booth No 612. **Circle No 370**

DUAL CENTRIFUGAL BLOWER

Model 2NB800 delivers up to 2000 cfm of air while running quietly at low speed. High motor efficiency helps hold down motor temperature and increase motor life.

You can order motors for any ac voltage and for single or 3-phase operation (single-phase motors are UL and CSA listed). Motor choice also embraces 2- to 6-pole units: 2- and 4-pole motors handle high back pressures, while the 6-pole unit operates at 1000 rpm. $150. Delivery, 8 to 10 wks ARO.

McLean Engineering Laboratories, 70 Washington Rd, Princeton Junction, NJ 08850. Phone (609) 799-0100. Booth No 1549. **Circle No 375**

Electromagnetic compatibility *is achieved through the use of military filter-pin connectors that allow systems to work in close quarters without interfering with one another. Also shown are feedthrough miniature filters. (Photo courtesy AMP Inc)*

EMI shielding and protective components

The electronic world is noisier today than ever before; fortunately, manufacturers offer a wide variety of aids to help you control electromagnetic interference.

Jim McDermott, Special Features Editor

Electromagnetic compatibility—the ability of electronic devices to function without being interfered with and without interfering with other devices—has assumed prime importance as the number of EMI noise-pollution sources grows. These sources include not only computers, switching power supplies and industrial, scientific and medical equipment, but also such incidental-radiation devices as electric motors, hand drills, home appliances, light dimmers and electric-tool speed controls. Fortunately, as the electronic environment has grown noisier, the arsenal of weapons in the war on noise has expanded.

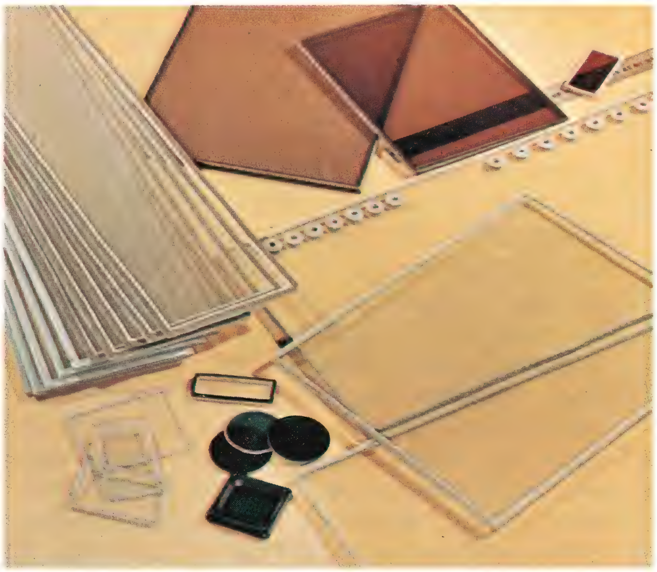
Fundamentally, you can attack EMI in two ways: prevent it from reaching susceptible circuits, or keep it contained within shielded enclosures where it can do no harm. In either case, the task requires eliminating the means whereby EMI travels from a source to a point of disturbance—radiation, conduction or a combination of both. For this job, you can use

- **Shielding** to exclude or contain the radiated EMI
- **Filters**—both low-frequency units for power and higher frequency devices for signals—to trap the EMI before it gets into or out of the equipment or circuitry
- **Transient absorbers** to protect the circuitry against high-voltage line, power-supply or other internal disturbances, or against static discharges.

Shielding

Shielding is the first line of defense in the battle against EMI. The metal variety is best: With the proper type, you can obtain virtually perfect protection (higher than 120-dB attenuation; see **box** entitled "How shielding works"). But today, sheet-metal enclosures have been replaced in many cases by molded-plastic cabinets and housings; such boxes weigh less, cost less

Conductive-elastomer seals *protect shielding integrity into the gigahertz region. These molded, extruded and die-cut seals from Chomerics provide environmental protection as well.*



See-through shields *reject EMI while providing good visibility. Metal mesh, laminated between glass sheets or cast in plastic like the Tecknit windows in the center, is the most transparent type. Conductively coated windows, like those in the upper center, are effective shields but not as easy to see through.*

Metal shields are best, but coatings prove adequate

to tool up for and produce, and provide the packaging designer with a great deal of freedom. Of course, plastic by itself is transparent to the entire EMI spectrum—from audio signals up through the hundred-gigahertz range. To cope with this deficiency, manufacturers have developed a variety of methods to produce good-to-excellent shields for plastic enclosures. They use aluminum foil, as well as conductive coatings applied by vacuum metallizing, spray plating, arc spraying and spray painting processes.

Lining cabinets or enclosures with *aluminum foil* is a labor-intensive process and is generally difficult to implement, particularly in enclosures with many curves and contours. Thus, this protective measure proves most useful in shielding small, planar areas. *Vacuum metallizing*, on the other hand, accommodates complex enclosures by evaporating a highly conductive metal film (usually aluminum 20 to 50 μin. thick) directly onto the plastic or paint substrate; its drawbacks include poor environmental resistance and relatively high cost. *Spray plating* deposits a reducing agent and a metal

Increasing emphasis on electromagnetic compatibility generates problems

Computers, peripherals and other digital devices are both sources and receivers of broad-band EMI. They are sources because they contain clock and other square-wave signals with high-frequency content; as computing speed rises, the spectrum of the EMI generated broadens, so digital circuits have great potential for interfering with other electronic equipment. But IC logic can also be affected by EMI, and this susceptibility will grow as the trend toward lower powered, lower voltage and more sensitive VLSI circuits grows. Complicating the picture still further are additional disturbances such as high-voltage power-line transients or static discharges from personnel to computer equipment, which can blow out ICs or wipe out memories.

If your digital system design is susceptible to EMI, you can use the variety of design tricks and components described in this article to make it EMI proof. Or you can consider redesigning critical signal paths to accommodate fiber optics. Because the latter approach represents a major change in design methods, we have deliberately avoided considering its details here. Instead, we refer you to EDN's Designer's Guide to Fiber Optics (January 5, January 20, February 20, March 5, 1978).

In addition to the foregoing considerations, a key factor in the war on EMI is the growing complexity of regulations governing its control: The EMI limits imposed by the US, West Germany and Canada will have an increasing impact on the incorporation of EMI control methods in commercial electronic equipment.

Current West German specs, which are widely followed in Europe, are tougher than those in the US; they are promulgated by the Verband Deutscher Electrotechniker (VDE), the Association of German Electrical Engineers. Until recently, EDP equipment in Germany was subject to VDE0875, which regulates the emissions from appliances, machines and installations with power inputs from dc to 10 kHz. This spec applies to *unintentional generators* of interference resulting as a byproduct of equipment operation. But now the VDE says that EMI from digital equipment results from *intentionally generated* signals—from clock and logic circuitry and particularly from switching power supplies. The latter generate a broad spectrum of energy in the 10- to 100-kHz range. So the VDE plans to place digital equipment under the more restrictive regulations of VDE0871—a move that will produce a whole new design ballgame.

In this country, the FCC's philosophy is to put an increasing emphasis on mandated electromagnetic compatibility. To this end, the Commission is proposing an amendment to Part 15 of its Rules and Regulations to define those points governing restricted-radiation devices, among other things. The FCC zeroes in on digital equipment in one item of the proposal that "includes computers, digital weight scales, data-processing equipment, tape recorders, electronic watches, switching power supplies and any (other) device incorporating digital techniques."

Under the amendment, the conducted and radiated emissions of these devices would be held to what many industry experts feel are excessively strict levels; switching-power-supply manufacturers, for example, claim that conforming to the new limits would call for costly redesign. The Computer and Business Equipment Manufacturers' Association (CBEMA) also feels the proposed standards are too restrictive; its counterrecommendations to the FCC are contained in "CBEMA/ESC5, Limits and Methods of Measurements of Electromagnetic Emanations from Electronic Data-Processing and Office Equipment" — recommended reading, as is the FCC's "Notice of Proposed Rule Making" in Docket 20780, which details the amendment to Part 15.

How shielding works

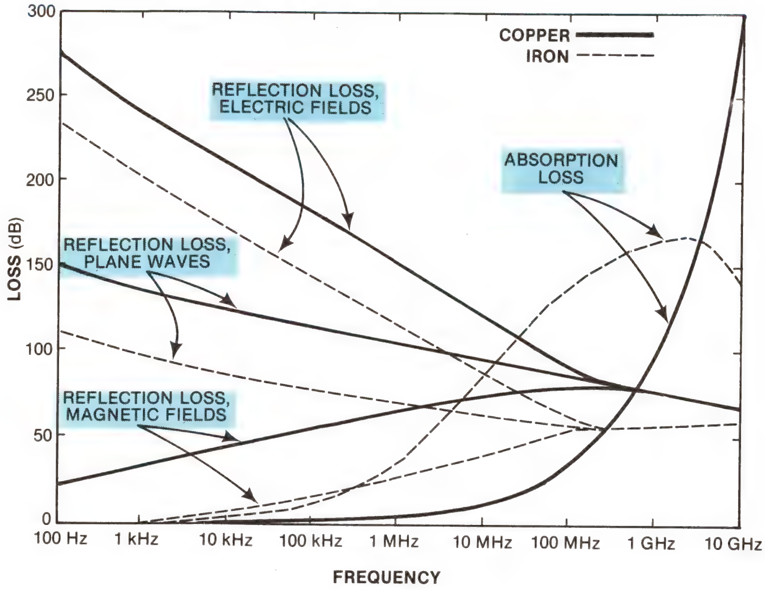
Shields protect against EMI disturbances carried by electromagnetic waves; such waves have two components: a magnetic-field vector and an electric-field vector. These two fields are orthogonal, and an electromagnetic wave propagates at right angles to the plane containing them. The relative magnitudes of the magnetic (H) field and the electric (E) field depend upon how distant the wave is from its source and on the nature of that source. The ratio of E to H is termed the wave impedance (Z_W).

If the source contains a large current flow compared with its voltage (a condition that might arise in a loop or transformer or in power lines), it's termed a current source, magnetic source or low-impedance source. In this case, Z_W is small. On the other hand, if the source operates at a high voltage and only small currents flow, the source impedance is high and the resulting wave is considered an electric field. At very large distances, $Z_W=1$ and the wave is a plane wave. Its impedance is 377Ω—that of free space.

If an electromagnetic wave encounters a discontinuity—a shield—it reflects if its impedance and that of the shield differ greatly; in that case, only a small amount of energy is transmitted across the boundary. Metals have an intrinsic impedance approaching zero because their conductivity approaches infinity; under these conditions, an electric wave with an impedance of a few hundred ohms is reflected. On the other hand, when obstructing a low-impedance magnetic wave, a metal will not reflect energy, but rather let it pass through—that's why it's so difficult to shield against magnetic waves.

No shielding is perfect, but it can be made so effective that under normal circumstances its attenuation is too great to measure. In general, shielding with an attenuation between 0 and 10 dB is considered poor; 10 to 30 dB is fair; 30 to 60 dB is average; 60 to 90 dB is good; 90 to 120 dB is excellent; greater than 120 dB is superior.

Shielding effectiveness is the sum of reflected energy losses (R), absorbed energy losses (A) and a correction factor (B) that can be ignored when absorption losses are greater than 10 dB. The absorption term is directly proportional to shield thickness; consequently, the greater the thickness, the better the shielding. Where magnetic shielding is required, particularly below about 15 kHz, losses arise almost totally from absorption. On the other hand, if protection from an electric field or plane wave is required, reflection loss predominates. Reflection losses for iron and copper shields appear in the **figure.**



From these relations, you can derive some tips on shielding design. First, magnetic fields are more difficult to shield than electric or plane-wave fields. And the lower frequencies of a magnetic field are more difficult to isolate than the higher ones. Second, a shielded enclosure usually provides adequate isolation at all frequencies if it is designed to absorb the lowest magnetic-field frequency specified. (If only electric fields are present, use the lowest plane-wave frequency.)

For further reading, you can find a wealth of information in the *EMI/RFI Gasket Design Manual* from Chomerics and the *EMI/RFI Shielding Handbook and Catalog* from Metex, both of which are available from the companies on request. Another valuable reference is the *Interference Technology Master,* an annual design guide from R&B Enterprises (Box 328, Plymouth Meeting, PA 19462, phone (215) 828-6236). It contains comprehensive analyses of EMI problems and solutions, as well as pertinent commercial and military specs.

salt—usually silver—onto the plastic, producing a high-conductivity pure-metal coating. But this coating is thin and fragile, and without an additional protective coating, sulfides can attack the silver.

Zinc makes a good shield

Because of the foregoing methods' disadvantages, shields produced by arc spraying or sprayed-on conductive coatings prove the most popular methods of shielding plastic cabinets. *Arc spraying* involves melting a metal, such as zinc, in an electric arc, then atomizing the molten metal and blowing it into the surface of the plastic. (This process requires a special wire-arc gun such as those produced by Tafa or Metco.) Although other metals such as aluminum, copper and silver can be used, zinc provides a good-to-excellent shield with a 50- to 70-dB attenuation over 1 MHz to 1 GHz. The zinc coating is about 5 mils thick and has a surface resistivity of 20 milliohms per square, according to Tafa. A limitation of this process, however, is that it is slower than ordinary spraying and less adaptable for use in high-volume production.

In systems where a shielding effectiveness of 30 to 60 dB over a 10-kHz to 1-GHz band is adequate, *sprayed-on conductive coatings* prove effective. The applied material is usually an organic paint filled with conductive particles like silver, copper-nickel or graphite. Attenuation of 80 dB is possible with the best of these coatings.

The coatings adhere to a wide variety of substrates with little or no surface preparation because of their organic binders, which also provide a buffer during thermal cycling. You apply them with conventional spray equipment; shielding effectiveness varies with the type of coating and the thickness to which it's applied.

Gary S Ross, materials engineer in the R&D Dept of Electro-Kinetic Systems, cautions that you should test such a conductive coating for shielding effectiveness, durability and ease of application. Adhesion to the substrate is especially critical; check it both before and after environmental cycling. Additionally, testing in high humidity at 140°F for 72 hrs can tell you if the coating will survive trouble from an unexpected source—shipping. (In summer, the temperature inside a truck trailer can easily reach 140°F at 90% relative humidity or higher. Some coatings can lose their attenuation effectiveness under these conditions.)

Silver: good but expensive

Of the various sprayed-on conductive coatings, silver exhibits the best conductivity and offers excellent shielding performance. But it's also the most expensive, costing more than 10 times as much as competing base-metal or graphite coatings. However, if cost is no

TABLE 1 — TYPICAL BROAD-BAND SHIELDING EFFECTIVENESS OF CONDUCTIVE COATINGS

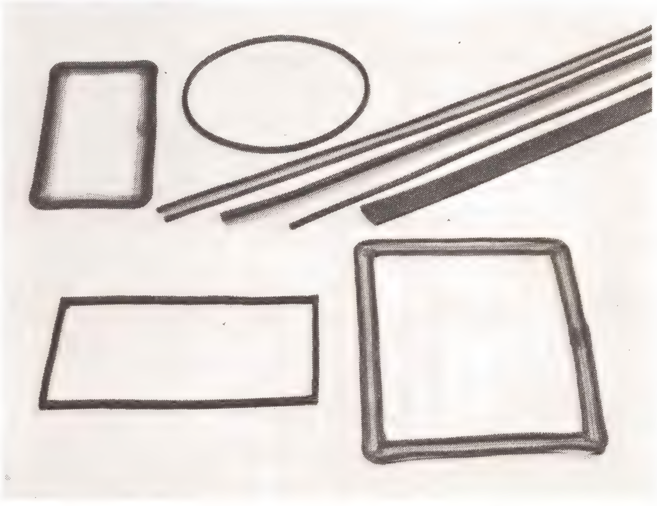
COATING MATERIAL	COATING THICKNESS (MILS)	SHEET RESISTANCE Ω/SQUARE (@1 MIL)	ATTENUATION (dB)
ALUMINUM PANEL (FOR REFERENCE)	62.5	≈0	65 - 100
SILVER PAINT	1.0	0.01	65 - 70
SILVER/GRAPHITE (2 COAT)	0.2/1.0	0.01/100	54 - 77
COPPER (FORMULA A)	2.0	8.0	20 - 54
(FORMULA B)	2.0	0.1	65
COPPER/GRAPHITE (2 COAT)	2/2	8.0/100	27 - 62
GRAPHITE (FORMULA C)	1.0	100	11 - 60
(FORMULA D)	2.0	20	30 - 60
NICKEL	2.0	1.0	65

object and performance is, you can formulate silver coatings to adhere to almost any substrate and to maintain conductivity and shielding in the most adverse environments.

Copper-filled coatings are cost-effective, but with them you must exercise caution, because in some binders copper has a tendency to oxidize as it ages, particularly in harsh environments. To overcome this problem, Electro-Kinetic Systems has developed a copper dispersion in a thermosetting epoxy copolymer that binds the metal particles in a tight, environmentally resistant matrix; such coatings have withstood thermal stress and prolonged humidity at 140°F. With 2- to 3-mil film thickness, typical coating sheet resistivity is less than 0.5 ohms per square—a value that produces attenuation of about 40 dB at most frequencies of interest.

You can also use coatings based on nickel in a wide range of applications; this metal resists oxidation and consequently mixes with a wider variety of paints than other base metals. Most air-dry nickel systems produce greater than 40-dB attenuation in a 2-mil thickness.

Graphite systems, which have a substantially higher sheet resistivity than metals (20 to 10k ohms per square, depending on the paint formulation, versus copper's less than 0.5 ohms per square), prove more effective for electrostatic-charge dissipation than for



EMI leaks through mating surfaces of doors and panels *are sealed by compressible conductive-metal-mesh strips and gaskets, like this variety from Tecknit.*

TABLE 2 — COMPARATIVE COSTS OF SHIELDING FOR PLASTIC CABINETS AND HOUSINGS

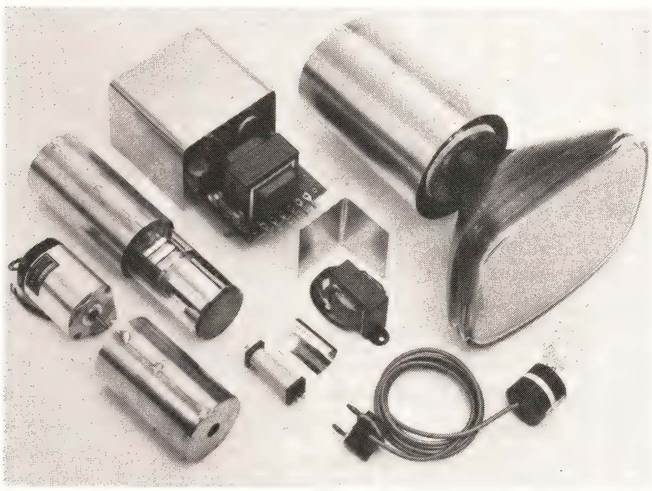
APPLICATION METHOD	COSTS ($ PER FT^2) MATERIALS	APPLICATION	TOTAL
SILVER COATINGS	4.00 - 10.00	0.20 - 1.00	4.20 - 11.00
VACUUM METALLIZING	0.25 - 0.75	1.00 - 4.00	1.25 - 4.75
SPRAY PLATING	0.40 - 0.75	1.00 - 2.00	1.40 - 2.75
ARC SPRAYING	0.40 - 0.80	0.50 - 4.00	0.90 - 4.80
BASE-METAL COATINGS	0.25 - 0.60	0.20 - 1.00	0.45 - 1.60
GRAPHITE COATINGS	0.10 - 0.50	0.20 - 0.50	0.30 - 1.00

shielding. But graphite can be blended with or coated over metal systems to provide relatively high degrees of shielding effectiveness at low material cost. For example, Acheson Colloid has produced a 2-coat system (graphite on silver) that furnishes a higher attenuation than silver alone **(Table 1).**

Seal up those EMI leaks

The shielding values specified by conductive-coating manufacturers and other sources invariably assume that the enclosure or cabinet is a perfect, intact shield. But in real life, cabinets have openings for controls, access panels, connectors, cooling vents, windows and other features. And EMI leaks into and out of these openings as if they were sieves. To maintain the highest shielding effectiveness, therefore, you must EMI-proof not only these openings, but also the mating surfaces of doors and panels, plus any slits and cracks. Fortunately, manufacturers such as Metex, Tecknit and Chomerics have developed a variety of shielding components for this purpose.

For sealing flat mating surfaces against EMI leaks, your options take the form of compressible, conductive gaskets. Some are made of flat or round knitted-wire mesh; others, of knitted-wire mesh mounted on an elastomer core; still others, of oriented or random wires bound in silicone elastomers; and finally, yet others are composed of metal-filled elastomers alone.



Magnetic shielding *protects against disturbing effects of low-frequency or dc fields. Preformed shields such as these from Magnetic Shield are widely available; you can also fabricate your own with sheet stock or magnetic foil.*

Just how well such a gasket seals against EMI depends to a large extent upon its shape and thickness, the type of metal in it and the compression forces on it. Compression can range from about 5 lb/in.^{2} for pliant gaskets to four or five times this value for stiff ones. Some gaskets also provide an environmental seal.

The type of wire incorporated in a gasket can affect your application. For example, Monel is highly resistant to corrosion, resilient and an effective EMI seal. You can use it in contact with aluminum panels, but in salt-spray or high-humidity environments, watch out: Electrolytic action can corrode the aluminum. Alternatively, tin-plated, copper-clad steel wire is more benign in contact with aluminum but is itself more susceptible to corrosion than Monel. And while aluminum mesh is compatible with aluminum mating surfaces, it is also mechanically weak.

Embedded-wire gaskets form good EMI seals; for ease of application, some of them come with an adhesive backing. These gaskets—provided in strips, sheets and die-cut shapes—consist of Monel, aluminum or nickel wires embedded in a silicone elastomer. For best performance, the wires are oriented perpendicular to the mating surface, although gaskets with randomly oriented wires are also available. To protect against strong magnetic fields, you can obtain embedded-wire gaskets with solid-copper wires plated with a tin alloy at the bare ends; these varieties also protect against atomic-blast-generated electromagnetic pulse (EMP).

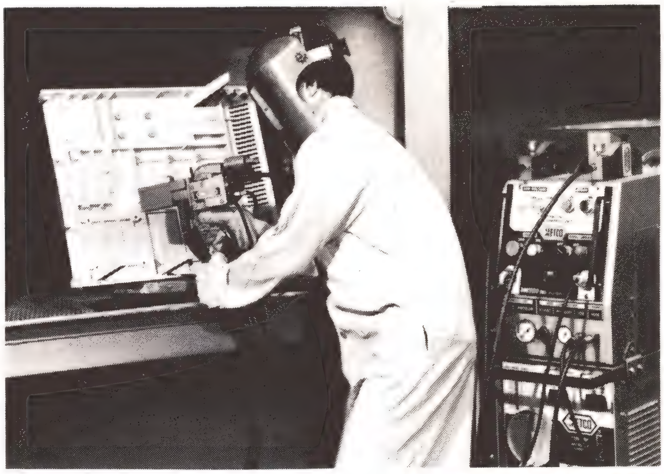
Gaskets seal out dust, moisture and EMI

While wire-type gaskets are the "old reliables," the newer conductive-elastomer gaskets, in which silver-coated glass microspheres, silver-plated copper particles or pure-silver particles are suspended in a silicone or fluorosilicone binder, are highly conductive and provide EMI protection into the gigahertz region as well as forming a hermetic seal. Like other elastomers, these gaskets (available in sheets 0.015 to 0.025 in. thick) come in a wide variety of molded and extruded shapes as well as in die-cut forms.

One limitation of these gaskets is that their shielding effectiveness is reduced by extended vibration: The greatest degradation occurs with the silver-coated glass microspheres; there's substantially less for silver-plated-copper and pure-silver particles. To overcome this problem, Metex has developed a composite shielding material, termed Armored Xecon, made of silver-plated particles in a silicone-elastomer matrix uniformly dispersed on a backbone of knitted wire. This material maintains its shielding effectiveness in vibrating loads as high as 200g.

EMI can even creep through cracks in welded seams. To make such slits, seams or joints EMI proof, you can use a variety of silver-filled caulking materials. For use with mating sliding surfaces, silver-filled silicone greases are recommended to minimize contact resistance. (Ford Motor Co uses conductive grease on spark-distributor rotors to reduce radiated EMI.)

Shield against magnetism with a variety of sheet stock



A thin coating of zinc *provides a good EMI shield for the inside of computer and peripheral-equipment plastic cabinets. Coatings a few mils thick are applied with arc guns like this one from Metco.*

Cover those cooling vents

Turning to the actual openings in your equipment, note that metal screens made of multiple layers of woven-wire mesh, placed over cooling openings, can raise attenuation in many applications. These screens look like and in some cases act like air filters and usually have EMI gaskets in their aluminum frames. They don't produce the highest possible shielding of an aperture, though, and the mesh impedes air flow to some extent.

If your design calls for the absolute minimum impedance to air flow plus maximum EMI shielding, use honeycomb ventilators. Their broad-band shielding results from making the dimensions of the hexagonal honeycomb cells act like waveguides operating beyond their cutoff frequencies. Typically aluminum, these filters often combine two layers, with the honeycomb structural foils orthogonal to each other to minimize directional effects. Should your requirements call for the rejection of high magnetic fields as well as electric ones, steel honeycomb panels will do the job—at a higher cost.

Windows exclude EMI

In cases where meters, controls or other system elements must be observed through a shielded enclosure, two types of windows are generally available: knitted-wire mesh and conductive transparent coating on glass or plastics.

You can laminate the mesh between two layers of glass or acrylic plastic, or—to resist shock and vibration—fuse or cast it into a solid panel of acrylic plastic. The wires of these mesh windows are small enough (2 to 4 mils) and the mesh openings numerous enough (10 to 30 per inch) to provide good see-through visibility (95%). The windows are available in standard sizes, complete with RFI gasketing.

Windows that use vacuum-deposited electrically conductive films to reduce EMI appear a little more opaque than the mesh types. The films can be deposited on glass, acrylics, polycarbonates and fluorinated plastics, but because vacuum metallizing is not a high-volume process, the windows are usually made to custom specs. Tecknit can produce units measuring up to 24×30 in.; the firm's standard coatings have a surface resistivity of 14 ohms per square, and their light transmission is 75% with plate glass. Coatings on both sides of the window increase the shielding value somewhat.

Shielding against magnetism

Although conductive coatings can shield plastic cabinets satisfactorily against the E fields of impinging radiation from a few hundred kilohertz to the gigahertz region, they are not effective against strong magnetic fields in the frequency range of dc to tens of kilohertz. As a result, the ac line-frequency field from power transformers and the dc fields from motors and solenoids can wreak havoc with such parameters as CRT-beam deflection and spot shape.

You can avoid these undesirable effects by applying ferromagnetic shielding to the devices, such as transformers, that generate strong fields—thereby containing those fields. But because this step in itself seldom effects a complete cure, you'll usually also have to apply shields to the sensitive devices, such as the CRT you wish to protect.

Magnetic shielding is available as sheet stock from several suppliers in standard thicknesses of 14, 20, 25, 31, 50 and 62 mils. You can also order it in plain or adhesive-backed foils ranging from 2 to 10 mils thick. And there is additionally a large variety of preformed shields that suit many common applications, such as transformers and CRTs.

The shielding itself comes in three grades: high saturability, high permeability and medium permeability. For example, MuShield's high-saturation material has a permeability range of 200 to 50,000; its saturation point lies between 18 and 20 kG. The company's medium-permeability material, usually used as an intermediate buffer shield, has a permeability ranging from 12,500 to 150,000 and saturates at about 15.5 kG. The high-permeability material has a minimum permeability of 80,000 at 40G, rising to a maximum of 350,000, with a saturation point at about 7.5 kG after annealing.

A note of caution: All of the manufacturer's specs for these materials give the maximum values for permeability, measured in dc fields. For ac fields, however, these values decrease; at 60 Hz they may be less than one-third their dc value. Take the resulting degradation in shielding effectiveness into account. Also, remember that creating magnetic shielding is largely an empirical process. Rather than getting involved in the math of this process, consult an application engineer.

Spiral wrapping looks good but has flaws

For a hands-on approach to magnetic shielding,

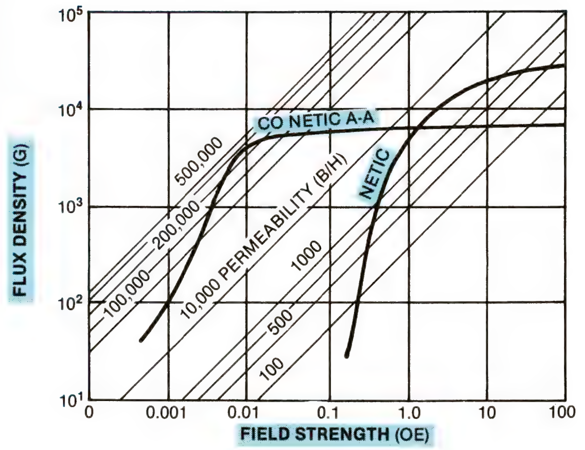


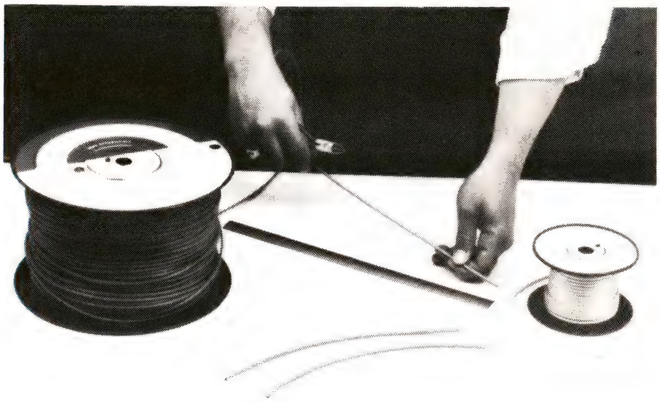
Fig 1—High permeability, low-saturation materials, *like Magnetic Shield's Co-Netic A-A, provide the best shielding in low magnetic fields. Higher coercive-strength materials, such as Netic, withstand more intense fields but provide less protection.*

obtain some sheet stock or foil, either plain or with adhesive backing, like that supplied by Advance Magnetics. Both sheet stock and foil can be cut and formed with minimum effort. When you use these materials to surround a device that's generating an interference field or must be protected against one, the shield acts like a magnetic shunt at low frequencies. At higher frequencies, eddy currents generated in the shielding oppose the interference field and thereby provide protection.

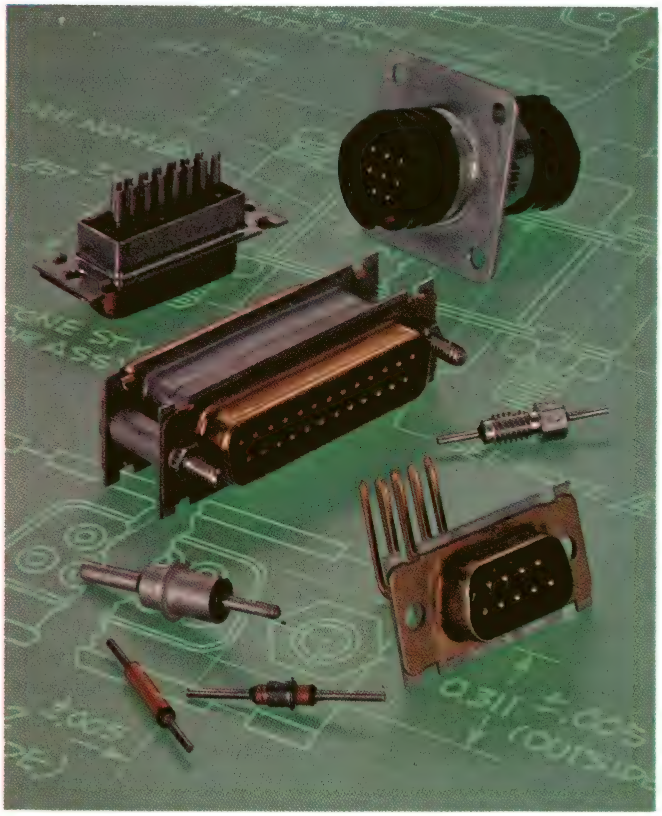
A rule of thumb to follow in applying magnetic-shielding materials is to start with a layer that provides a shielding of about 1G per mil of thickness; this figure in turn produces about a 40-dB attenuation. A typical material of this type is Magnetic Shield's Co-Netic A-A, whch has a saturation level of about 7500G **(Fig 1).** The firm's Netic material, on the other hand, withstands a 22G field before it saturates and provides a shield of about 4G per mil. But with it, you'll only achieve about 10 to 15 dB of attenuation per layer.

Form your shields from a blank of flat sheet stock and join the edges or ends of an enclosure by seam welding, or by lapping the edges and spot welding them. For prototypes, you can tape the lapped edges, but provide plenty of overlap to minimize any air-gap effect. Remember that flat sheet or foil placed between an interference field and a component to be shielded proves effective only when the shield ends extend far enough away from the component. Otherwise, the diverted interfering flux is reradiated from the edges of the flat shield, with an accompanying decrease in attenuation.

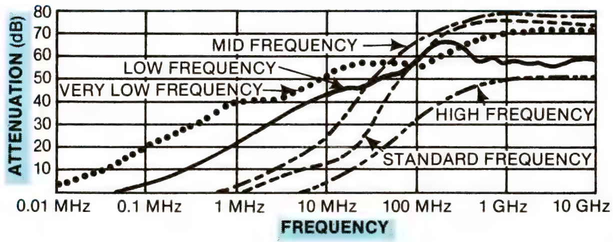
When you wrap foil around a device, separate each layer with tape or insulation. Also, stagger lap joints when constructing multilayer shields. But never spiral-wrap shielding material, because this configuration produces a magnetic pole on the inside edge of the



Suppressing EMI in microwave equipment *is easier with Lossyline cable from Capcon. Attenuation rises rapidly in the microwave region because of absorption by lossy material in the cable; the material is also available as tubing that you can slip over other wires or cables.*



Ceramic-and-ferrite filter elements *are part of AMP's Quiet Line family of feedthrough filters and rack-and-panel connectors.*



You can select the frequency bands *to be attenuated by changing connector filter pins. Representative characteristics available are shown in these curves from Bendix.*

foil that reradiates the interference field.

Can the ferromagnetic alloys used for magnetic shielding do double duty as EMI shields? Sometimes. They are not as conductive as copper, but they can form a good electric (as well as magnetic) shield at frequencies up to 40 or 50 kHz. At higher frequencies, though, the RF skin effect dominates, and electric-field shielding drops off; restoring it requires high surface conductivity, which you can achieve by plating the magnetic shield with a layer of copper sufficiently thick to satisfy the skin-effect requirements at the maximum frequency of interest.

Filters

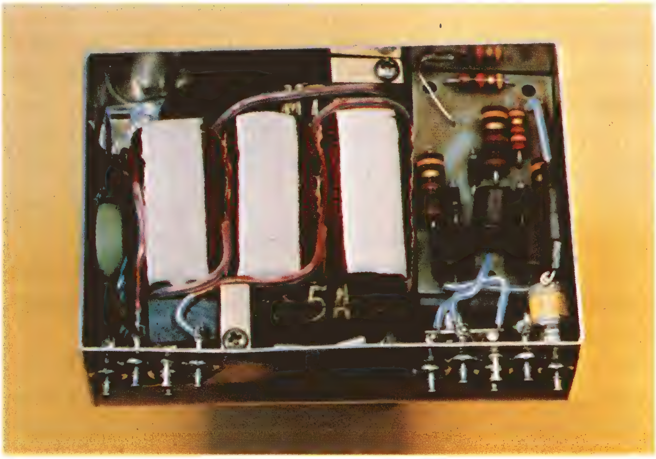
While shielding techniques can make equipment EMI proof against external radiated interference, protecting it against conducted EMI is another matter. Such conducted interference enters through the power-line connector as well as through signal and control lines. And EMI generated inside a device—in, say, a switching power supply—can exit through those same conductors.

Blocking such conducted EMI calls for low-pass filters. For the power line, you can use any of a wide variety of filters produced for this purpose by such manufacturers as Corcom, Hopkins Engineering, Sanders Associates and Sprague Electric. For the signal lines, you can incorporate miniature feedthrough-type low-pass filters into shield walls, or you can use connectors such as rack-and-panel, pc-board or flexible-circuit types that have miniature low-pass filters integrated into their pins.

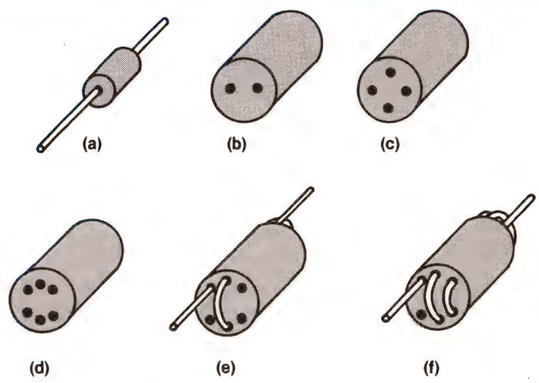
In digital equipment, most susceptibility problems are caused by common-mode interference that appears as a noise voltage between all incoming power lines and ground. This EMI can be conducted from another source some distance away on the line, or it can be induced into the line. Differential-mode interference, on the other hand, generally arises from a source close to the susceptible equipment. Noisy equipment, such as switching regulators and switching-type power supplies, generates both common- and differential-mode EMI over a broad frequency band. The filters employed to bring conducted EMI into compliance with MIL-STD-461 and the foreign VDE0875 must attenuate both types of EMI.

Choosing a satisfactory line filter is a cut-and-try procedure for several reasons. First, published insertion-loss data is useless because manufacturers obtain it in a 50Ω-to-50Ω test circuit, yet neither the power line nor your equipment is likely to present a 50Ω resistive impedance. Second, the impedances of the power line and your equipment are typically not accurately known over the important frequency range of 150 kHz to 30 MHz. As a result, you can't calculate

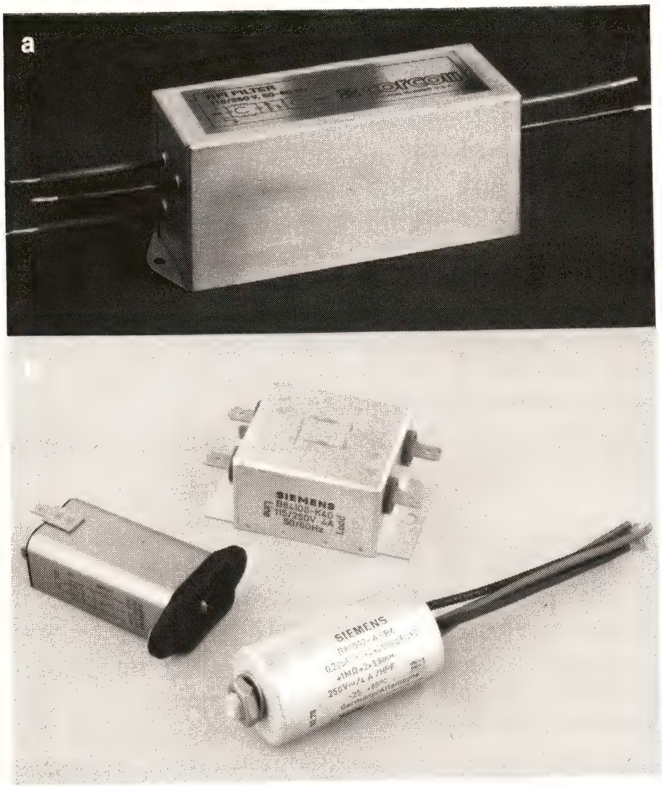
Tame the hash from digital sources *with filter connectors like this ITT Cannon DB25, developed for use with flexible wiring.*



Special power-line-filter requirements *call for custom designs. This potted and sealed avionics 3-phase line filter uses three E-core inductors. Produced by Sanders Associates, it has a filter capacitor mounted on the side of the case; transient detection and protection come from components on the circuit board.*



Shield beads *of lossy ferrite are a low-cost means of attenuating EMI in close quarters. One or more beads slipped onto a wire prove effective at frequencies as low as 1 MHz. Multihole beads* **(b, c and d)** *provide higher attenuation when you thread wire through them; 6-hole beads are widely used in 1½* **(e)**- *and 2½* **(f)**-*turn configurations.*



Power-line filters *come in various shapes and filtering capability. Filters from Corcom* ***(a)*** *and Siemens* ***(b)*** *exceed US standards for electromagnetic compatibility and also meet the tougher European regulations.*

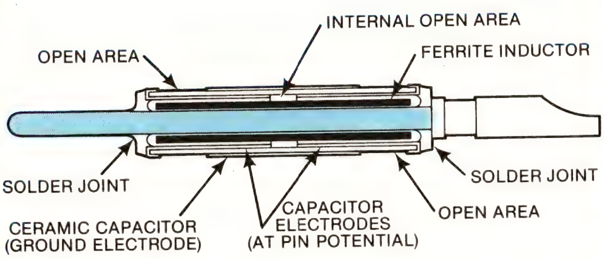


Fig 2—Construction of miniature EMI filters *is the same for both feedthrough units and those inserted as filter pins into military and commercial connectors. Typical construction is represented here by that of a Bendix pi-type filter pin.*

Filter contacts *are small enough for use in high-density connectors, such as the Bendix 128-contact device at left. Single- and double-length filter pins used for this purpose appear in the foreground.*

the transfer characteristics of the power-line filter.

Fortunately, some empirical methods help here. According to Corcom, you can consider a power-line filter to be a mismatched network at high frequencies. In fact, the greater the filter's mismatch to the terminating impedance of the equipment, the more effective the filter is in attenuating the EMI frequencies. Considered another way, in equipment containing switching power supplies and shunt regulators, the power-line impedance and the equipment impedance itself will both be low. In equipment containing linear power supplies, however, the picture changes at high frequencies. There, the power-line impedance is low but the equipment impedance is high.

From this data you can draw some conclusions. First, because the power line is a low impedance, the filter, as a mismatching network, must present to it a high impedance—a series inductance. Ditto for the equipment when its impedance is low. But if the equipment presents a high impedance, the line filter must look like a low impedance—a shunt capacitor. Based on these relationships, Corcom recommends using a 2-element L-type filter when the equipment presents a high impedance and a 3-element T-type filter when equipment impedance is low.

Once you've selected a filter, put it in your equipment and measure its susceptibility to conducted EMI in both common and differential modes. You must evaluate the filter in the equipment in this manner, because even though two filters may have, for example, the same 1-kHz values of inductance and capacitance, they might not perform identically. That is, two filters with the same insertion-loss characteristics as specified by MIL-STD-220 might have entirely different characteristics when connected to your devices. The converse is also true: If you have two qualified sources, don't ask them to meet the same MIL-STD spec requirements just because they both pass your in-line tests.

Protect your signal lines

EMI filters for signal lines are today almost always "high-frequency"-type low-pass filters, in which the capacitive and reactive elements are integrated into a small, sleeve-like assembly—an arrangement that contrasts with the rather bulky power-line filters, which use discrete capacitors and inductors. Each miniature low-pass filter is fabricated as a single capacitor element, a single or multiple pi-element filter or a distributed lossy filter. Units come in several mechanical styles, such as bolts or eyelets or as the pin-and-sleeve combination used in filter-pin connectors. They're available in a wide range of attenuation characteristics, ranging from a few decibels at 50 or 100 kHz to 70 or 80 dB at 1 GHz and above. These filters are fabricated as feedthrough elements by AMP and Erie; in turn, they form part of the MIL-STD (and other) connector lines offered by AMP, Amphenol, Bendix, ITT Cannon and Erie.

The basic miniature-filter elements are tubular ceramic devices that hold the equivalent of a bulky

discrete filter. They consist of an outer ceramic-dielectric sleeve, which provides an exceptionally high capacitance per unit volume, and an inner lossy ferrite sleeve **(Fig 2).** Contact to a central conductor, or a central connector pin that carries the signal, occurs to the inside of the ceramic capacitor; the outside of the filter connects to a shield or a connector ground plane. The lossy ferrite provides the equivalent impedance of a lossy distributed coaxial line.

The capacitance of these small devices is quite high. For example, a filter for a #26 connector-pin contact achieves about 7000 pF, while the smaller Size 22 contact reaches 6000 pF in Bendix connectors.

Transients *from 8 to 1800V can be suppressed with metal-oxide variable resistors (MOVs) like General Electric's, shown here before and after encapsulation. The white areas on the MOV discs are the contacts. Larger sizes pass more breakdown current when maintaining the voltage across them and the protected circuit at safe levels.*

Voltage spikes and surges *that can destroy semiconductors and microprocessors are clamped to safe levels by special avalanche breakdown diodes such as these TransZorbs from General Semiconductor Industries.*

Connectors using filter pins differ in certain mechanical aspects, depending on the manufacturer. For example, to provide mechanical strain relief to the brittle ceramic capacitor element, Bendix houses it in an epoxy encapsulant. Amphenol, on the other hand, approaches this problem by making contacts to the ceramic with conductive elastomers rather than by the usual soldering process.

Because of the characteristics of the filter pins' ceramic-titanite materials, maximum capacitance is achieved at about 50°C and with zero voltage across the capacitive element; capacitance decreases with reduced temperature and increased voltage. However, manufacturers usually spec this quantity at 25°C and normal working voltage.

Suppliers of EMI shielding and protective components

For more information on EMI shielding and protective components, contact the following firms directly or circle the appropriate numbers on the Information Retrieval Service card. Suppliers are keyed to their products as follows: (1) Conductive coatings and adhesives, (2) wire gaskets and seals, (3) conductive-elastomer gaskets and seals, (4) magnetic shielding, (5) power-line filters, (6) signal filters, (7) filter connectors, (8) ferrite beads, (9) transient-voltage absorbers, (10) cable shielding, (11) conductive lubricants, (*) see text.

Ablestick Laboratories (1)
833 W 182nd St
Gardena, CA 90248
(213) 321-6252
Circle No 385

Acheson Colloids Co (1, 11)
Box 288
Port Huron, MI 48060
(313) 948-5581
Circle No 386

Acme Chemicals & Insulation Co (1)
166 Chapel St
New Haven, CT 06513
(203) 562-2171
Circle No 387

Ad-vance Magnetics Inc (4)
625 Monroe St
Rochester, IN 46975
(219) 223-3158
Circle No 388

AMP Capitron Div (6, 7)
Elizabethtown, PA 17022
(717) 367-1105
Circle No 389

Amphenol Canada Div (7)
44 Metropolitan Rd
Scarborough, Ontario
Canada M1R 2T9
(416) 291-4401
Circle No 390

Amuneal Manufacturing Corp (4)
4737 Darrah St
Philadelphia, PA 19124
(215) 535-3000
Circle No 391

Bendix Corp (7)
Electrical Components Div
Sidney, NY 13838
(607) 563-5383
Circle No 392

Capcon Inc (*)
147 W 25th St
New York, NY 10001
(212) 243-6275
Circle No 393

Chomerics Inc (1, 2, 3, 11)
77 Dragon Ct
Woburn, MA 01801
(617) 935-4850
Circle No 394

Computer & Business Equipment Mfrs Association (*)
Suite 1200
1828 L St NW
Washington, DC 20036
(202) 466-2288

Conducto-Lube Co (11)
8603 SW 17th St
Portland, OR 97219
(503) 244-2230
Circle No 396

Corcom Inc (5)
2635 N Kildare Ave
Chicago, IL 60639
(312) 384-7400
Circle No 397

Cornell Dubilier Electronics (5)
150 Ave L
Newark, NJ 07101
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Although filter-pin elements have been around for several years, there have been some new developments in this area, according to L A Krantz, filter-project engineer at Bendix. Filter-pin capacitors have been improved to tolerate 600V spikes, as called for by MIL-STD-707. And starting from an RF current-carrying capacity of 0.25A a year ago, Bendix has reached 3A. Also, filter design has been improved to accept microsecond-rise-time pulses of 1500V to meet FCC telecommunications requirements.

Ferrite beads trap EMI

The lossy ferrite materials used in the fabrication of the miniature EMI filters and filter-pin connectors are also produced separately in the form of "shield beads" with one to six holes. The single-hole units provide a simple, effective component for attenuating EMI on a wire lead without any loss at dc or low frequencies. They typically cost $0.03 in 10k quantities and even less in larger amounts.

These beads, offered by Fair-Rite Corp, Ferroxcube and Stackpole Carbon, slide onto the lead of a component or a conductor carrying EMI. They find high usage on power-supply leads and connections to ground and between circuit stages. The beads are equivalent to a series RL impedance; above about 1 MHz, their resistive (lossy) component rises rapidly to dissipate the undesired high-frequency EMI.

Where single-hole beads don't provide enough impedance, you can use the 2-, 4- or 6-hole units; use of

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Bay Shore, NY 11706
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the latter with 1½ or 2½ turns of wire has become an industry standard. To increase the absorption power of these beads even further, slip one or more of them on a wire, then connect a capacitor in series with that wire and tie the load in parallel with the capacitor. The beads' damping value is then multiplied by the value of the capacitor's reactance.

Lossy lines prove effective

There's also a new approach to EMI suppression for microwave equipment such as radar, countermeasure devices and telecommunications units: the LossyLine element from Capcon. Essentially a coaxial line in which the dielectric space between the center conductor and outer shield is filled with a dispersion of ferrite and other lossy particles in a flexible silicone-elastomer binder, it eliminates mismatch, reflections and high VSWR inherent in conventional suppression filters.

In the Capcon element, attenuation arises from absorption rather than reflection. A 2-ft length provides a 3-dB attenuation at 10 MHz, rising to over 100 dB at 200 MHz to 100 GHz. For greater low-frequency attenuation, you replace the straight center conductor by a conducting helix encased in the lossy medium; then, a 2-ft length has an insertion loss of 3 dB at about 1 MHz, rising to greater than 100 dB around 50 MHz.

The LossyLine can be equipped with a variety of standard coaxial connectors; you can also trim it with scissors to your exact attenuation requirements. It handles currents from 0.5 to 50A and voltages as high as 100 kV; a line designed to operate at 1A at up to 500V dc or 125V ac costs $1.60 per ft (100 ft). The lossy material is also available in the form of tubing that you can slip over wires and cables. Priced at $1.30 per ft (100), the tubing provides substantially better performance than ferrite beads, particularly above 50 MHz. Packaged versions of the LossyLine filters achieve 20-dB attenuation at 20 kHz, rising to over 120 dB at 120 kHz.

Transient suppressors

Damaging high-voltage transients can enter your equipment through the power line and power-supply transformer. Excessive transient-noise pulses can be generated in microcomputer-based systems by the operation of power switches and relays, and by other capacitive- and inductive-load switching. Then, too, switching transistors generate their own brand of transient mischief, and electrostatic discharges can penetrate circuitry with kilovolt spikes. Such spikes and glitches can destroy semiconductors and wipe out microprocessors and other digital circuitry.

Line transients caused by lightning strikes demand special protective devices, such as spark gaps or gas-discharge tubes that crowbar the line. But for general-purpose transient protection, two types of components are often used at the semiconductor-device and system level: metal-oxide varistors (MOVs) and avalanche-diode voltage clamps. Both types of suppressors present a high resistance across the ac or dc line they protect; for MOVs this standby resistance is in the order of kilohms, while for the diodes it ranges from kilohms to megohms. When the voltage across these devices rises to a critical breakdown value during a transient, they conduct strongly, clamping the voltage at or close to the breakdown level.

MOVs, available from GE, Panasonic and Siemens, are voltage-dependent resistors manufactured by sintering a mixture of zinc and other metal oxides into a ceramic disc. Contacts attach to each side, and the breakdown voltage depends on the oxide mixture. Diode clamps, on the other hand, are silicon pn-junction devices in which avalanche-breakdown voltage is controlled by junction characteristics. They are in essence a refined type of zener (EDN, August 20, pgs 105-109).

For semiconductor-device and circuit protection, MOVs are available with breakdown characteristics as low as 18V dc (Panasonic). They can, however, be fabricated to hold off voltages as high as 1800V. And they are bidirectional devices, so they handle both ac and dc. Breakdown ratings increase in increments of 5 or 6V from 18 to about 50V dc; above that value, increments are greater.

The short-circuit current-carrying capacity of an MOV is a function of the energy it can dissipate without an excessive temperature rise; peak currents vary from 1 to 20A or more, depending on the size of the device rather than its voltage rating. Note, however, that repeated breakdowns at maximum currents lower the peak current that can be handled.

Diode protectors such as General Semiconductor's TransZorbs clamp as little as 6V—a feature useful in 5V digital circuits. TRW, Semicon and Unitrode also produce lines of clamping diodes to protect microprocessor systems against transients. Breakdown voltages range from about 6 to 25V dc; peak pulse breakdown currents range from about 50 to more than 200A. For ac applications, TransZorbs and other diode protectors come in a back-to-back configuration.

The response speed of both MOVs and clamping diodes is slowed by lead inductance. In a real-world application, MOVs clamp in about 10 to 20 nsec; diodes take less than 2 to 5 nsec. The tradeoff is one of performance vs speed: MOVs take longer to initiate clamping action and don't clamp as sharply, but they typically sell for about one-fourth to one-fifth the price of a diode. **EDN**

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μP development systems offer the tools users need

The newest development systems support multiple users and perform real-time emulation; separate emulation-memory buses prevent contention.

John Marshall and **Sam Lee,** Hewlett-Packard Co

The advent of clustered development systems furnishes designers of μP-based products with the tools they need to reduce the increasing costs of software development. In a system providing fast access and parallel data transfer via an interface bus, such as the configuration shown in **Fig 1,** each station operates independently, without delays.

Multiplexing the expensive peripherals in this type of system permits each programmer to take advantage of the hard disc's fast response time; the shared data base proves efficient, too, because all stations can access one copy of system programs and program modules—no more searching for a program's most recent version. The system's multiuser capability also allows users to buy only as many stations as they need for a current project while leaving open the possibility of easy future expansion. The incremental cost of adding a software-development station in this manner compares favorably with that of additional floppy-disc-based single-user development systems **(Fig 2).**

The newest development systems furnish a second major advantage. An architecture that provides full-speed testing of code execution in a manner virtually independent of a development system's execution speed gives such systems a flexibility which guarantees that their usefulness will outlive the present generation of μPs. As a result, a user can calculate the development system's useful life on the basis of equipment usage rather than technological obsolescence. As does the multiuser capability, this feature permits buying only the hardware needed now; accommodating a new processor then only requires buying the appropriate emulator and software (assembler and other programs) for that device.

The result? On a system supporting multiple programmers, each station can accommodate both hardware and software development work for a different processor. The user equips the station with the appropriate emulator; it gets its software from the shared disc.

Emulation tests in real time

A complete development system should be able to test whether or not the code modules produced on it will work with the target μP. One way of performing such a test is to simulate the target processor's execution: The development system acts as if it were the system under test, reading the code and executing the instruction just like the μP eventually will. If this simulation can occur in real time, the process is termed emulation.

A more thorough test of the code uses a plug-in device that is pin compatible with the target processor and responds exactly as that processor does; this device executes instructions at the target μP's highest rated speed. The advantage of such a hardware/software device—a processor emulator—over emulation performed strictly in software (ie, real-time simulation) is that it not only tests code in real time, but it also tests that code's execution in coordination with the prototype hardware, exercising the hardware and ensuring that it's bug free in its real-time operation mode.

In the same manner, a user can emulate the target system's memory by mapping development-system memory into the executing processor's address space—overlaying the target memory. This procedure permits placing a program in RAM and testing it by making the target processor (or emulator) think it's addressing its own on-board ROM space.

Until now, performing both processor and memory emulation on systems built around architectures such as the ones depicted in **Fig 3** required the sharing of a memory bus by the host processor and emulator processor. The result? One of the processors generates

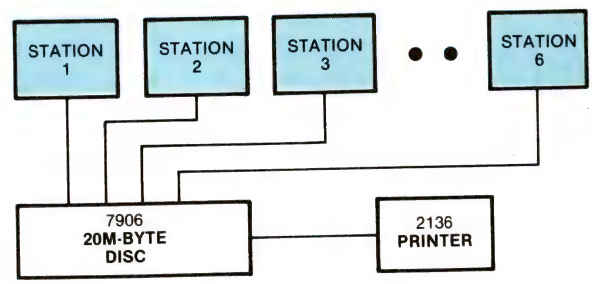


Fig 1—Up to six development stations *can share a common data base in this clustered development system. Programmers and hardware designers can thus work in parallel; all of them have immediate access to the latest versions of software. This version of the clustered-development-system concept is implemented in Hewlett-Packard's HP64000 (see pg 99 in this issue); Futuredata offers a system with similar overall configuration, but its detailed architecture varies.*

Testing code in real time eliminates subtle bugs

Wait states whenever both of them attempt to access memory simultaneously. If the emulator processor is forced to wait, its code execution can hardly be defined as occurring in real time—yet many emulators operate this way, providing only the illusion of real-time testing. Thus, bugs that affect only real-time operation can pass the emulation test, possibly remaining undiscovered until the product reaches the field.

To effectively deal with this problem, a development system should provide a separate memory bus for the emulator memory (**Fig 4**). With this provision, the host processor uses its own memory for most of its work; if it should require access to the emulation memory—to examine a location's contents, for example—it can gain such access over the host-emulator communication bus without interrupting the execution of the system under test. (The second interface depicted in **Fig 4**, labeled "control signals," provides run control.)

Defining a development system

The competitive nature of the μP-product marketplace determines the importance of development systems: The companies able to turn products around quickly and inexpensively are the winners, and the ability to do that calls for capable development systems—systems that, as described, aid both hardware *and* software development.

The development cycle for a μP-based product typically follows the flow chart shown in **Fig 5**. The hardware loop on the right-hand side is familiar and relatively easy to implement, it's the left-hand side that presents problems. Here, the steps that involve integrating the software and hardware into a product are the ones that benefit most from the use of a state-of-the-art development system.

Until recently, most development systems were

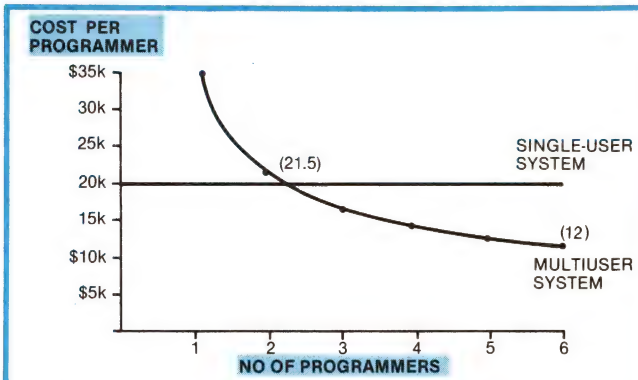


Fig 2—Multiuser systems *allocate high-performance peripherals among several users; their initial costs are higher than those of single-user systems, but the incremental costs of adding programmers can be smaller than for single-user systems. The graph illustrates the per-programmer costs of adding software-development stations to the HP64000 versus typical single-user-system costs.*

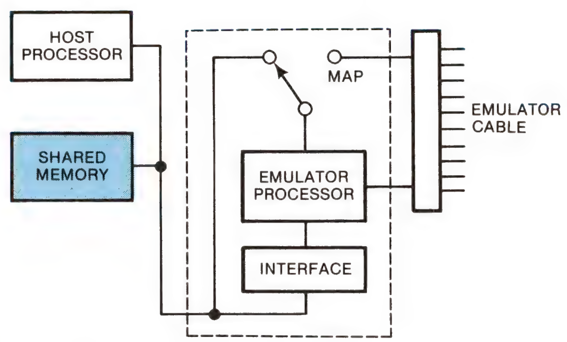


Fig 3—Most development systems *allocate memory between the host processor and target processor or emulator, causing bus-contention problems.*

Designing program modules

Modular design is (or should be) a hardware-design cliché. And the same reasons that make modularity essential in hardware design should prompt software designers to do their work in modular form.

Software tools should thus allow production of relocatable modules that a programmer can link together to form a complete program. The following guidelines to aid in those efforts come from *6800 Assembly Language Programming*, by Lance Leventhal (copyright © 1978, McGraw-Hill Inc. Used with permission of Osborne/McGraw-Hill Inc).

1. Use modules 20 to 50 lines long. Shorter modules are usually a waste of time, while longer ones are seldom general and can be difficult to integrate.

2. Try to make modules reasonably general. Differentiate between common features like ASCII or asynchronous-transmission formats, which will be the same for many applications, and key identifications, which are likely to be unique to a particular application. Major changes such as different character codes should be handled by separate modules.

3. Take extra time in developing modules such as delays and display handlers, which will prove useful in other projects or in many different places in the program under development.

4. Try to keep modules as distinct and logically separate as possible.

5. Do not try to modularize simple tasks in cases where rewriting the entire task might prove easier than assembling or modifying the module.

Note the importance of implementing each design decision in only one module. A change in any of these decisions will then only require changes to that module alone.

either restricted entirely to the software side of **Fig 5** or constrained in hardware-emulation speed by their architecture. And if a user did buy a system that provided all of the development tools required for a given μP, a newer μP would likely require faster system execution—making the expensive system obsolete. As a result, users have either stayed with older chips, given up on the idea of performing emulation in real time or bought a new development system for each new μP type.

The newest development systems deal effectively with these problems. For example, the traditional methods of placing code in a product involve putting the code into PROM, plugging in that PROM and running the system. When a bug rears its head, the programmer develops a solution, edits the source code, assembles (or compiles) the source, relinks the program modules, burns a new PROM and tries again. This method quickly proves not only labor intensive, but expensive: The cost of programmer time and wasted PROMs can raise a product's cost significantly.

With a development system like the HP64000, however, users can write their programs into emulator (RAM) memory that overlays the ROM space in the target system, using the development system's memory-emulation capability. Once they're assured that the code works (in real time, of course), an integral PROM programmer eases placement of the code in PROM. With the PROM installed in the target system (with the processor emulator still in place), a final test of the code occurs. Replacing the emulator with the target processor then produces a working product.

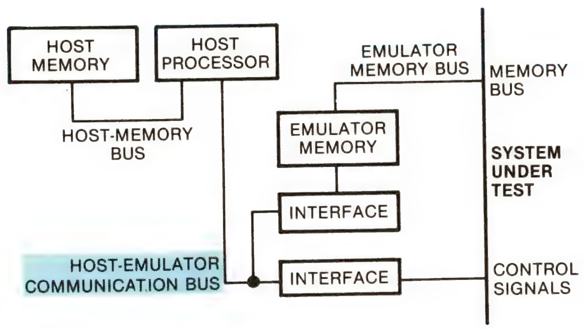


Fig 4—A separate bus *to provide emulator/target-processor access to emulation memory makes emulation speed in the HP64000 virtually independent of host-processor speed.*

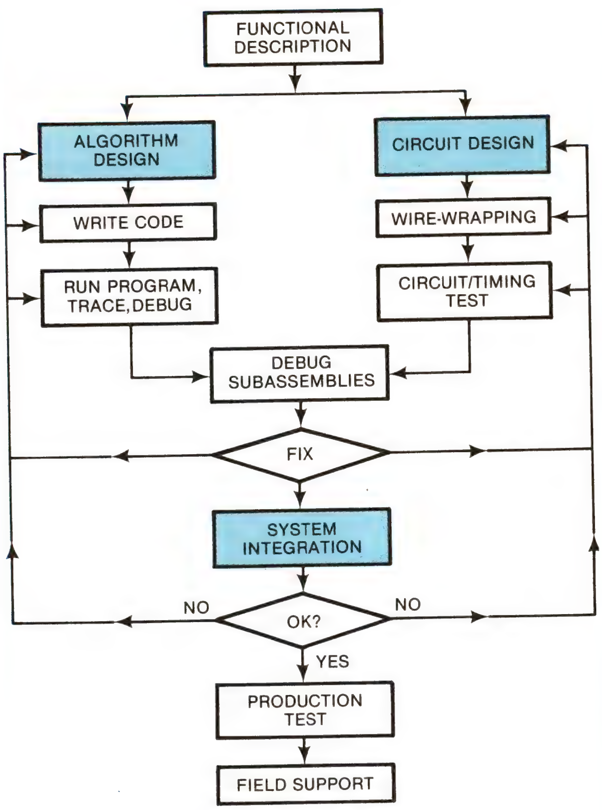


Fig 5—The development cycle's critical point *arises upon integration of the software into the prototype hardware—a process that typically requires several stages of testing and several iterations.*

Shopping for development systems

It's evident that complete mastery of the costly

Making the useful simple

A programmer survey at Hewlett-Packard's Colorado Springs, CO facility has revealed that software designers spend 49% of their time editing and debugging programs. This figure points up the impact that providing adequate editing and debugging tools can have on a development system's cost-effectiveness.

Taking advantage of the performance of high-speed hard disc, a system like the HP64000 can keep part of its user manual on disc, providing sophisticated prompts that explain the current functions of redefinable "soft keys." Such keys permit the entry of complex commands (and command sequences) with one keystroke, virtually eliminating syntax errors. Furthermore, well-written prompts can eliminate user confusion, shortening the learning curve.

Using the soft-key strategy consistently throughout the editor, debugging tools and operating-system interface allows users to proceed from one task to the next without changing their mental set to adapt to a new set of tools and syntax. The format stays the same—the syntax is readily evident and explained.

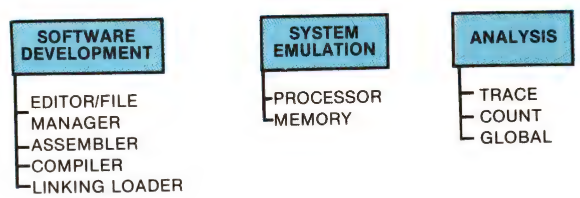


Fig 6—The complete solution *to development problems features tools that smooth every stage of the process.*

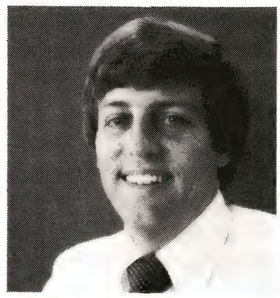
development cycle requires evaluating the cycle's inherent problems and providing tools that increase designers' productivity. These tools must be powerful, but they must also be easy to use. **Fig 6** summarizes the necessary features; each of these tools is implemented differently by various manufacturers.

A complete shopping list of development-system needs includes:

- A high-performance operating system with a flexible file manager
- A user-oriented editor
- The compilers, assemblers and/or interpreters that reflect the user's staff's programming skills
- Adequate RAM for the expected development tasks
- Adequate mass storage (disc) for maintaining accessible copies of tested program modules and software tools
- An integral PROM programmer
- Debugging tools.

This list reflects the true nature of the development task and provides sufficient flexibility to allow modification and expansion of the job at hand. With it, plus a consideration of the issues raised here, a rational choice of a development system is possible. **EDN**

Authors' biographies



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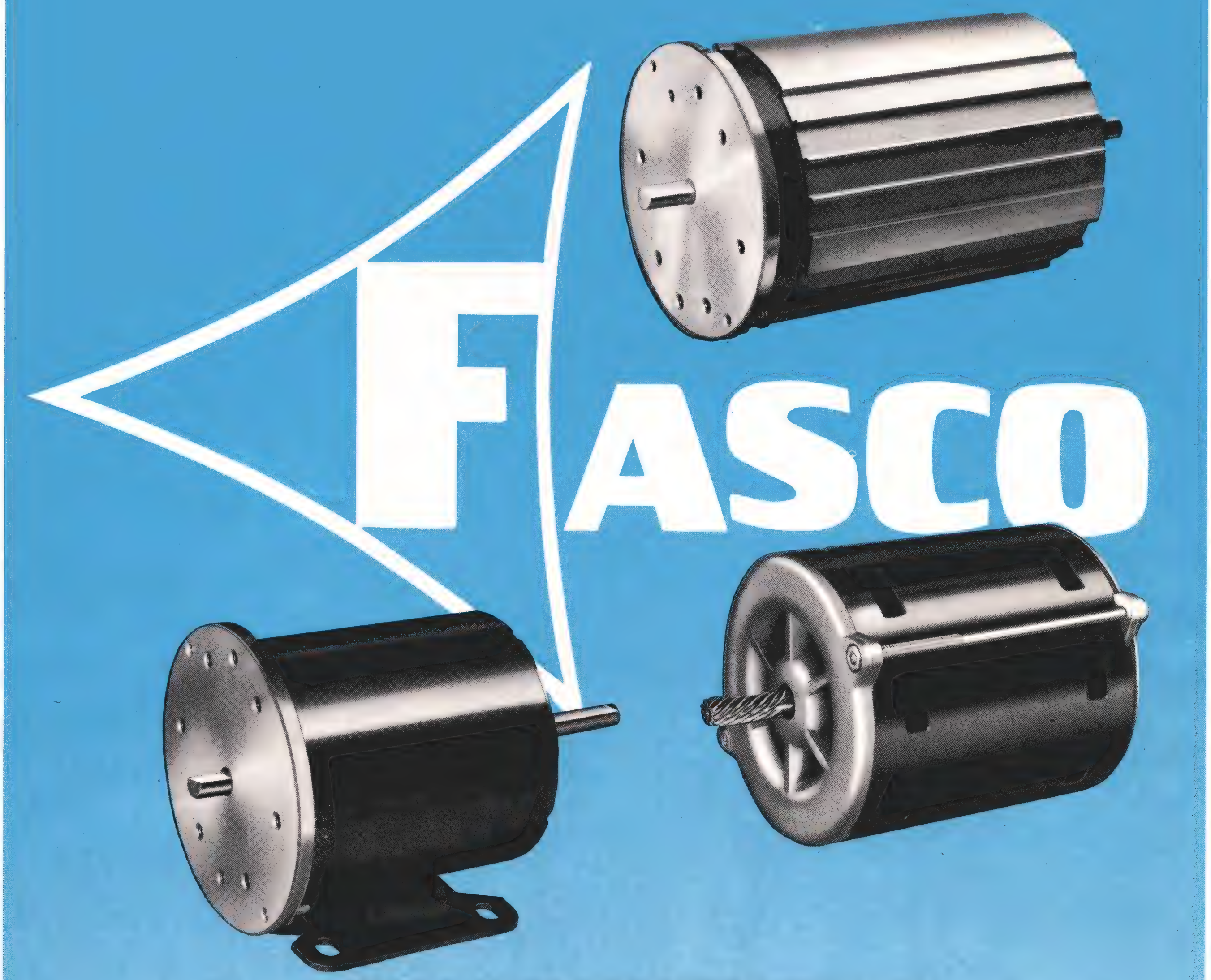
Sam Lee, product manager at Hewlett-Packard's logic-development-systems operation, holds BSEE and MSEE degrees from Texas Tech University. Another 10-yr veteran with Hewlett-Packard, Sam is an instrument-rated pilot.

Article Interest Quotient (Circle One)
***High* 476 *Medium* 477 *Low* 478**



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This electronic control loop conserves energy by reducing the voltage applied to a lightly loaded motor. It cuts no-load power by a factor of 2 or 3 while increasing power factor from 0.2 to 0.8. Slowdown due to the voltage reduction averages less than 2%.

Frank J Nola, NASA

Relatively simple and inexpensive circuitry can improve the power factor and reduce the power dissipation of a partially loaded induction motor. When operating below full load, this type of motor can exhibit power factors as low as 0.1 or 0.2. As a result, relatively large currents flow, while very little work is performed; hence, power losses occur at all points in the distribution system (including the motor windings) even though no mechanical power is delivered. An electronic control system, however, can raise power factor from 0.2 to 0.8 and provide significant energy savings **(Fig 1).**

The controller, shown in block-diagram form in **Fig 2,** reduces power losses by sensing the phase lag between voltage and current. It feeds this information to circuitry that forces a motor to run at a constant, predetermined optimum power factor, regardless of load or line-voltage variations (within the motor's limits). Specifically, when the load is reduced, the controller's solid-state switch (triac) reduces the applied voltage, minimizing wasted power. As the load increases, it in turn increases the voltage to the proper operating level. The controller works with most motors without modification.

Triac ON time varies with load

The reactive volt-amps (VA) rating of an induction motor remains high when the motor is unloaded or partially loaded. Single-phase motors show unloaded currents about 90% of rated load current; unloaded 3-phase motors (5 hp or less) use about 50% to 60% of rated current. These currents cause heat losses in both the motor and the utilities' distribution systems. In fact, power companies often charge users of many motors a premium for poor power factors arising with cyclic loads.

Power input to a motor equals $VI\cos\theta$. Because the current remains high in an unloaded motor, the phase angle (θ) between voltage and current shifts with the load. Typically, the current can lag the voltage by 80° in an unloaded motor or 30° when the motor is loaded. Phase angle, then, is the parameter that must be

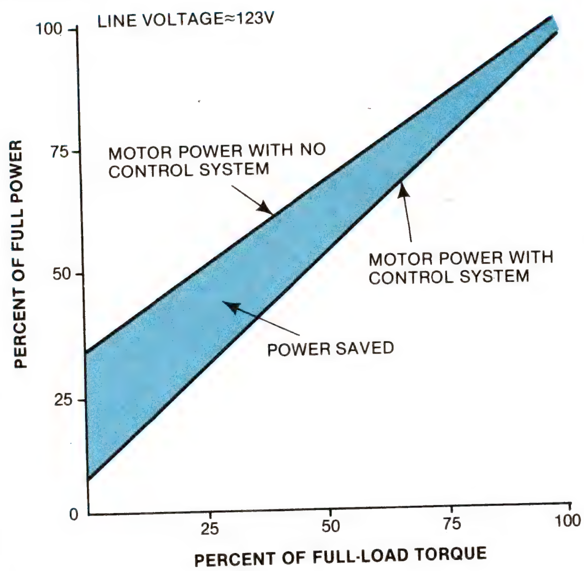


Fig 1—Most induction motors *are designed to operate with a high flux density to give good performance at full load. Therefore, the losses associated with this high flux density result in poor efficiency when the motor operates at reduced loads. By automatically reducing the voltage in such cases, the power-factor controller described in this article reduces losses considerably, as this data—averaged from tests made on a ⅓-hp split-phase motor and ⅓- and ¼-hp capacitive-start units—shows. Applied to a 15-hp motor, the circuit has paid for itself in 3 months.*

This article contains excerpts from NASA Tech Brief MFS-23280 and its Technical Support Package, Power Factor Controller. For more information, write to the Director, Technology Utilization Office, Marshall Space Flight Center, AL 35812, or phone (205) 453-2224. The patent for the invention (#4,052,648) is owned by the US government, but licenses for commercial development are available at no charge; contact the Patent Counsel, Marshall Space Flight Center, AL 35812, or phone (205) 453-0020.

Triac ON time keeps phase angle constant

measured and controlled to achieve efficient power consumption.

In the controller, the line voltage and its inverse are squared by squaring amplifiers IC_{1A} and IC_{1B}, as indicated by $\bar{E}$ and E, respectively, in the timing diagram (**Fig 3**). Each current pulse sensed by R_1 is squared by similar amplifiers (IC_{1C} and IC_{1D}), as indicated by I and I′ in **Fig 2.** ANDing $\bar{E}$ with I and E with I′ and then ORing the two results produces a pulse train that has a pulse width proportional to θ. When acted on by a low-pass filter (IC_{2A}), the dc or average value of this voltage becomes proportional to the phase angle. This voltage is summed with a command voltage from potentiometer P_1 that indicates the desired phase angle. The difference of the two voltages—the system error voltage—is then compared with a ramp synchronized with the line voltage's zero crossings. Finally, a voltage comparator (IC_{2B}) detects the intersection of the sloped portion of the ramp and error voltage, forming the triac's turn-on pulse.

As the load on the motor decreases, a corresponding slight change in the phase angle causes the error to drop and intersect the ramp at a lower point. This action moves the firing pulse to the right, along the sine wave, causing the triac to turn ON for a shorter time and lowering the applied voltage. Conversely, an increase in load causes the firing angle to move to the left, applying more voltage to the motor. Thus, a phase angle is commanded, and the high gain of the feedback loop varies the applied voltage, forcing the motor to operate at the desired phase angle regardless of load. Because the current is never higher than the minimum

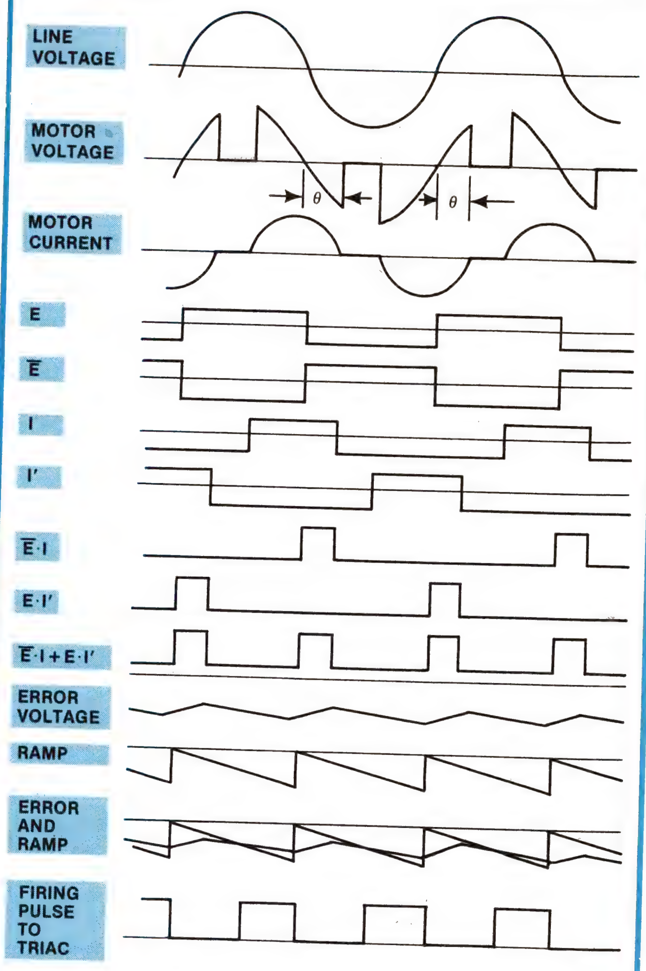


Fig 3—Voltage is applied to the motor *by the triac for a portion of each positive and negative half cycle of the line voltages. When the device switches ON, the windings' inductance prohibits a rapid current rise. The current reaches a peak, then follows the voltage down as it approaches zero, but with a finite lag. Of course, the triac inherently remains ON until the current goes to zero.*

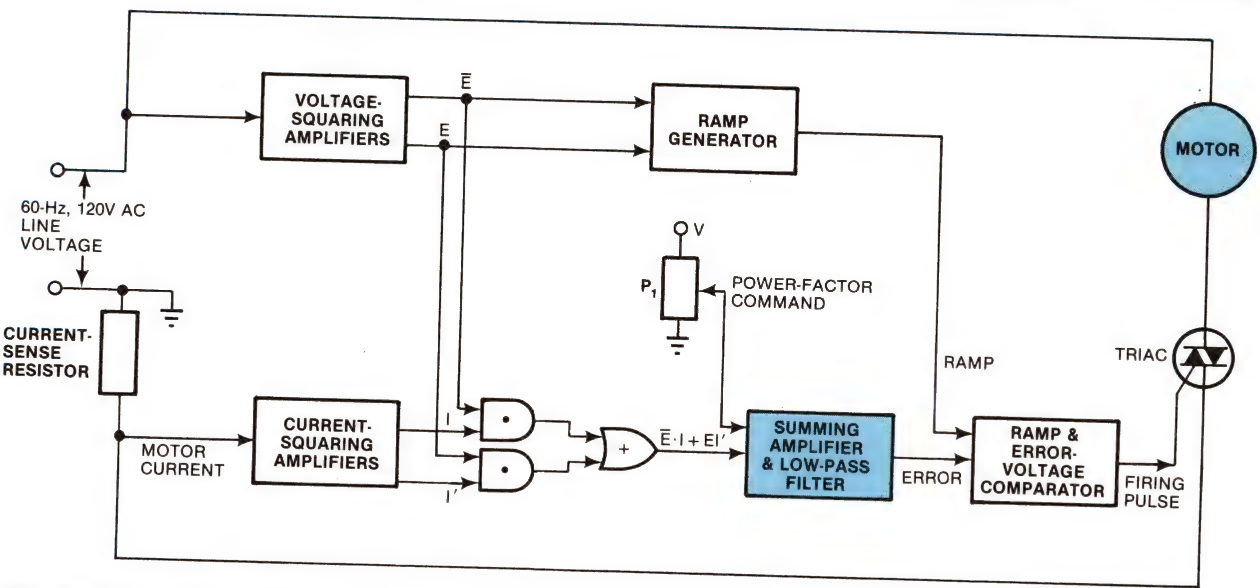


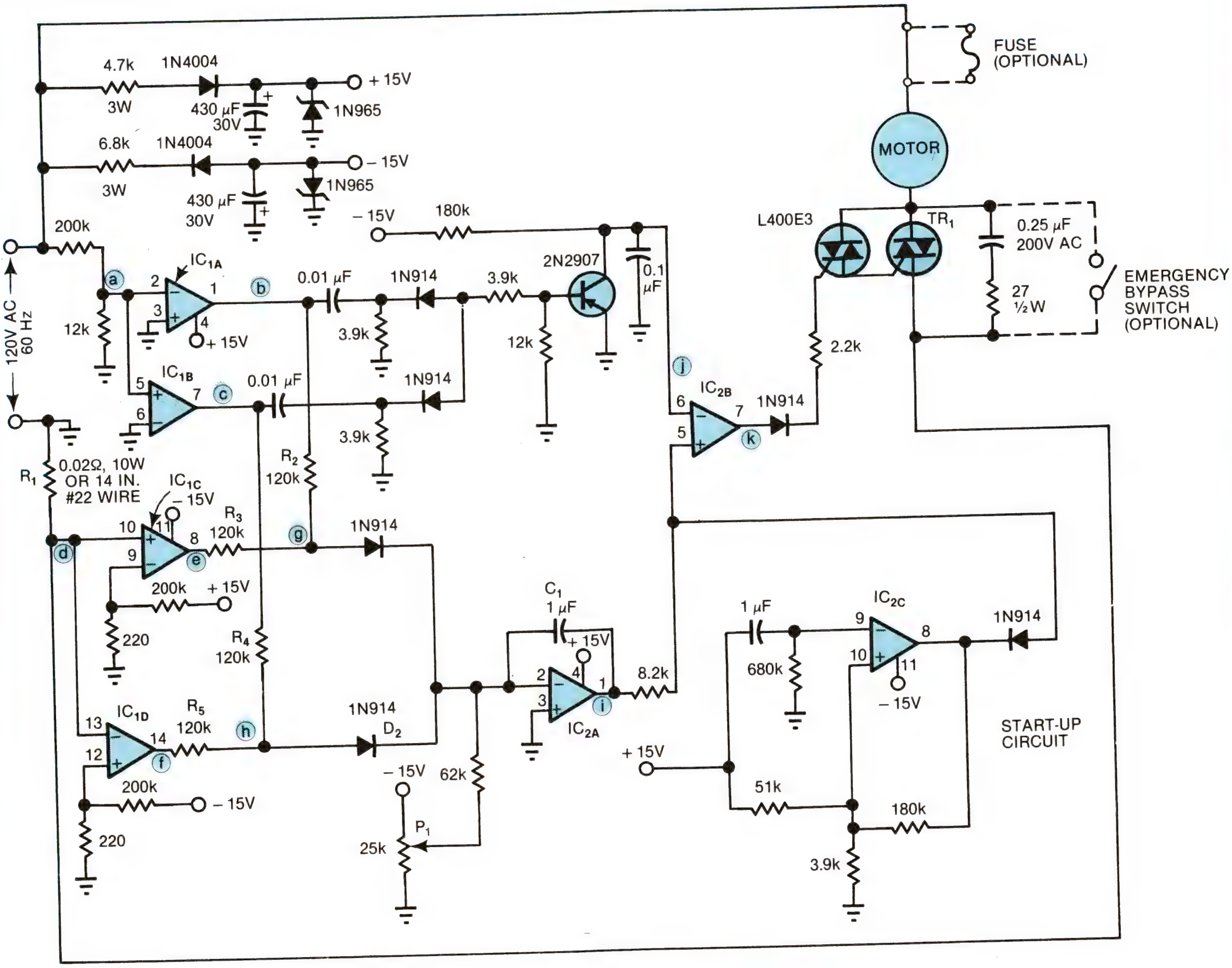
Fig 2—Response time *of the power-factor controller is limited by the filter time constant required to smooth the phase-angle feedback voltage.*

amount required for a given load, motor losses remain low.

A low-power power saver

The controller for a single-phase motor **(Fig 4)** puts the preceding discussion into perspective. Its operating characteristics follow those just described, but with one exception: IC_{2C} performs a turn-on delay function. Because the power supplies in the upper left-hand corner of the schematic have been designed for minimum power loss, IC_{2C} must delay the controller's turn-on for about 4 sec, allowing the power-supply voltages to reach the point where they can turn the triacs ON. Note, though, that a shorter delay might be acceptable.

To minimize the controller's overall power consumption, all op amps are low-power-type LM324s. These op amps in turn dictate the use of a 200V triac with a 3-mA



NOTES
1. IC_1, IC_2 = LM324
2. TR_1 = MAC 36-6 (2N6161), IS320 OR EQUIVALENT (400V, 25A)
3. IC_{2D} NOT USED
4. ALL RESISTORS ¼W UNLESS OTHERWISE INDICATED
5. ALL CAPACITORS 30V DC UNLESS OTHERWISE NOTED
6. POWER TRIAC REQUIRES HEAT SINK
7. CAUTION: NORMAL HOUSEHOLD VOLTAGES ARE PRESENT IN THE CIRCUITS SHOWN. CAUTION SHOULD BE EXERCISED WHILE THE CIRCUIT IS ACTIVE TO PREVENT POSSIBLE ELECTRICAL SHOCK. CIRCUIT IS COMMON TO ONE SIDE OF LINE VOLTAGE.

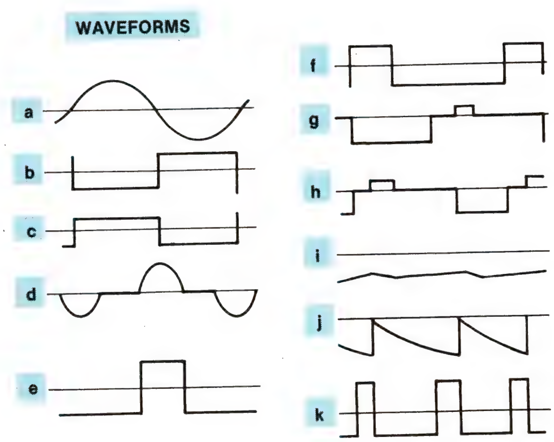


Fig 4—Besides cutting no-load power *by up to 60%, this controller increases single-phase-motor life by allowing such a motor to run cooler. At present, 22 companies have received no-cost licenses for commercial development of this patented NASA invention. In this implementation of the general controller scheme described in this article, IC_{2C} performs a turn-on delay function.*

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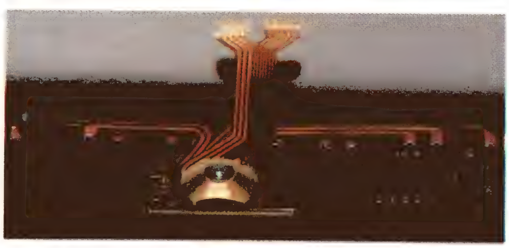

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Hughes Gold Dot Interconnection System — Patent No. 4,125,310 with other patents pending.

gate. (The L400E3 device shown is available from Teccor Inc, Box 669, 1101 Pamela Dr, Euless, TX, 76039; phone (817) 267-2601.)

The components connected by dotted lines near the motor and triac are optional. The controller doesn't apply extra stresses to a motor, but if your motor doesn't incorporate an internal fuse, you might consider adding one to the controller itself. Also, although the electronics should prove highly reliable, a bypass switch would enable equipment to operate in the event of component failure.

What about 3-phase motors?

As noted, single-phase motors require no modifications to use this controller. However, the straightforward application of the power-saving technique to wye-connected 3-phase motors requires connecting the wye internal to the motor or to the neutral of the 3-phase line, then placing a triac with its firing circuitry in series with each phase. The phase angle θ is sensed in only one phase; the error signal controls all three phases. If this approach seems unworkable, the controller concept is still valid—at least two patent licensees have succeeded in applying it to a wye-connected motor *without* a connection to the wye.

The controller circuit has also been applied to a delta-connected motor. Again, the direct approach places a triac in series with each winding inside the delta, but opening the delta might not be absolutely necessary. Two-voltage delta motors require no modification, of course, because all necessary leads are external to the motor. **EDN**

Author's biography

Frank Nola, an aerospace engineer at NASA's George C Marshall Space Flight Center, AL, designs electronic control systems for spacecraft and their associated experiments. He received his BSEE from the Univ of Miami and has done graduate work at the Univ of Wisconsin and the Univ of Alabama. For recreation, Mr Nola enjoys fishing.

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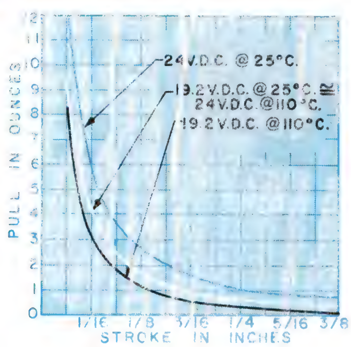
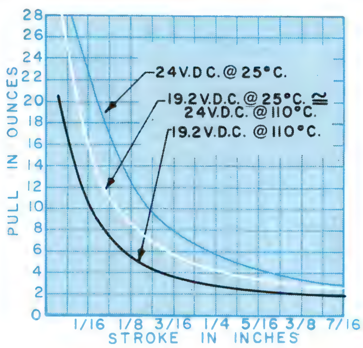


T-4 (⅞" long) Intermittent duty



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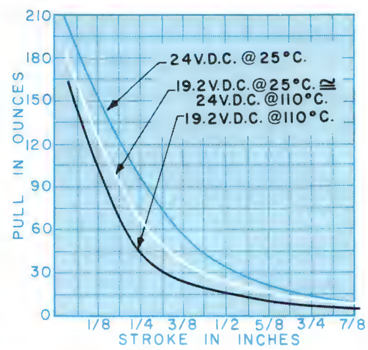

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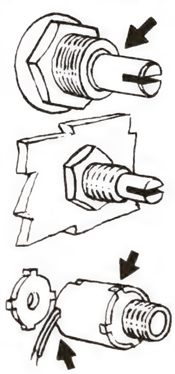

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Dual variable op-amp IC simplifies complex analog designs

With linearizing diodes, low noise and tight device matching, this operational-transconductance-amplifier pair provides cost-effective solutions to analog processing problems from dc to 9 MHz.

Hal Wittlinger and **Debra Nissman**,
RCA Solid State Div

The CA3280 IC consists of two *variable* op amps, each of which outputs a current (I_{out}) proportional to its differential input voltage (e_{in}) and its transconductance (g_m):

$$I_{out}=e_{in}g_m.$$

A device with such characteristics is designated an operational transconductance amplifier (OTA).

The CA3280 is more than just two CA3080s

An operational transconductance amplifier (OTA) has all the characteristics of the more common operational voltage amplifier except that its output impedance ideally approaches infinity rather than zero. Thus, an OTA's forward gain is characterized by transconductance rather than voltage gain. Additionally, RCA's CA3280 dual OTA provides a means to externally bias each of its amplifiers. The IC's transconductance parameters can be controlled and varied by adjustment of the amplifier bias current (I_{ABC}).

This design allows operational modes not easily obtained with other devices. For example, the OTA's isolation of input and output from each other and from the power supplies permits 4-terminal operation of the amplifier at frequencies down to dc. Such operation was previously only available with transformers—and only with ac.

Improved specs

When operated into a suitable load resistor and with feedback, the CA3280 suits a wide variety of traditional op-amp applications, including those for its predecessor OTA, the CA3080.

But the CA3280 surpasses the CA3080 in several performance areas, including input error terms, output current drive, noise and distortion **(table).** Additional advantages come from the device's linearizing diodes and from its construction: The chip is designed with cross-coupling of critical circuitry. This interdigitation reduces amplifier dependence on thermal and process variations, and it assures excellent matching of the two amplifiers on chip. The 16-pin plastic-packaged device receives gold-metallized silicon-nitride passivation to produce tenfold improvements in MTBF.

CONDITIONS: 25 °C, V_{SUPPLY} = ± 15V

CHARACTERISTIC	I_{ABC}	MIN	TYP	MAX
INPUT OFFSET VOLTAGE	100 μA		0.25 mV	0.5 mV
INPUT OFFSET VOLTAGE CHANGE	1 μA TO 1 mA		0.5 mV	1 mV
TEMP = −55 TO +125 °C	100 μA		3 μV/°C	5 μV/°C
NOISE VOLTAGE @1 kHz	500 μA		8 μV/√Hz	
PEAK OUTPUT CURRENT	500 μA	± 350 μA	± 410 μA	± 650 μA
SUPPLY CURRENT/AMP	500 μA		2 mA	2.4 mA
COMMON-MODE REJECTION RATIO	100 μA	94 dB	100 dB	
FORWARD LARGE-SIGNAL TRANSCONDUCTANCE	50 μA		0.8 mmho	1.2 mmho
OPEN-LOOP TOTAL HARMONIC DISTORTION @ 1 kHz, R_{LOAD} = 15kΩ V_{OUT} = 20V_{P-P}	1.5 mA		0.4%	
BANDWIDTH R_{LOAD} = 100Ω	1 mA		9 MHz	
SLEW RATE (OPEN LOOP)	1 mA		125 V/μsec	
OUTPUT RESISTANCE	100 μA		63 MΩ	

These specifications *are for the high-performance version of the CA3280, designated the CA3280AG.*

The CA3280's linearization diodes extend its voltage-input range

Each of the CA3280's OTAs incorporates an amplifier-bias-current (I_{ABC}) terminal. Because most electrical characteristics of a CA3280 circuit are externally controllable through adjustment of I_{ABC}, the IC's OTAs suit many applications. Additionally, important amplifier characteristics—such as transconductance, bandwidth, power dissipation, bias current, output current and input and output resistance—vary linearly with respect to I_{ABC}.

Each amplifier includes on-chip linearization diodes and diode-bias circuitry, which, when activated, permit a much wider input-signal range, reduce distortion and allow higher output current. The diode-bias-terminal current (I_D) provides additional gain control.

You can use the CA3280 in voltage-controlled filters and amplifiers—use of such circuits in electronic music, voice and sound synthesis and fast-acquisition phase-locked loops is increasing. Descriptions of tunable OTA filters have appeared elsewhere; these filter techniques utilize the linearly variable dynamic-impedance feature of the OTA.

Many OTA applications besides those for voltage-controlled filters employ gain control via I_{ABC}. For example, you can use half of a CA3280 to construct an amplitude modulator with a carrier frequency of 3 MHz and a modulating signal of 10 kHz **(Fig 1a).** The circuit shown is governed by g_m=(16 mmhos/mA)×I_{ABC}.

High CMRR reduces circuit complexity

One of the more difficult problems in instrumentation is the conversion of a transducer's differential output signal to a single-ended signal suitable for further processing. **Fig 2a** shows some of the techniques commonly used in this differential-to-single-ended conversion. With these systems, resistor ratios must be matched within 0.01% to obtain 80 dB of CMRR—excluding amplifier effects.

Use of a CA3280 produces a simpler, high-performance system. The inherent CMRR (94 dB min) of this OTA, coupled with its high input impedance (0.5 MΩ) guarantees high common-mode rejection for low source impedance **(Fig 2b).** Note that this circuit's output, because it is a current, may be referenced to a level other than the amplifier's ground. A current output also enjoys greater noise immunity in high-EMI environments.

As shown, the configuration in **Fig 2b** has a limited differential input-voltage range of only ±25 mV before signal compression occurs. You can compensate for this behavior—characteristic of all bipolar differential amplifiers—by using another of the CA3280's features—the linearizing diodes.

Linearizing diodes extend input ranges

When you drive the IC's input from a current source and activate the on-chip linearizing diodes **(Fig 3a),** the CA3280 input transfer characteristic goes from the s-curve in **Fig 3b** to the linear transfer curve shown in **Fig 3c.** Aside from the obvious improvement in linearity, the diodes also provide temperature compensation. The normal temperature coefficient of a bipolar differential amp is about −0.33%/°C; the diodes reduce this value by at least an order of magnitude. Use of the diodes also provides a second means of gain control in addition to I_{ABC}.

A simple way of considering this additional control is to assume that the diodes' dynamic impedance (R_D) shunts the input signal. The diode current I_D modulates R_D; in the CA3280, the scaling factor for this modulation is about 35Ω/mA. Because there are two input diodes, the dynamic impedance is actually 70Ω/mA. With two 10k input resistors, as in **Fig 3a,** the actual signal input e_{in} equals (16Ω/20k)×E_{IN}. For a load resistance of 15k, the amplifier gain is g_mR_L=16 mmhos×15k=240. Thus, a simplified basic transfer relationship can be derived for the amplifier gain: $A=K_1R_L\times(K_2/(R_1+R_2))$, where K_1= 16 mmhos/mA

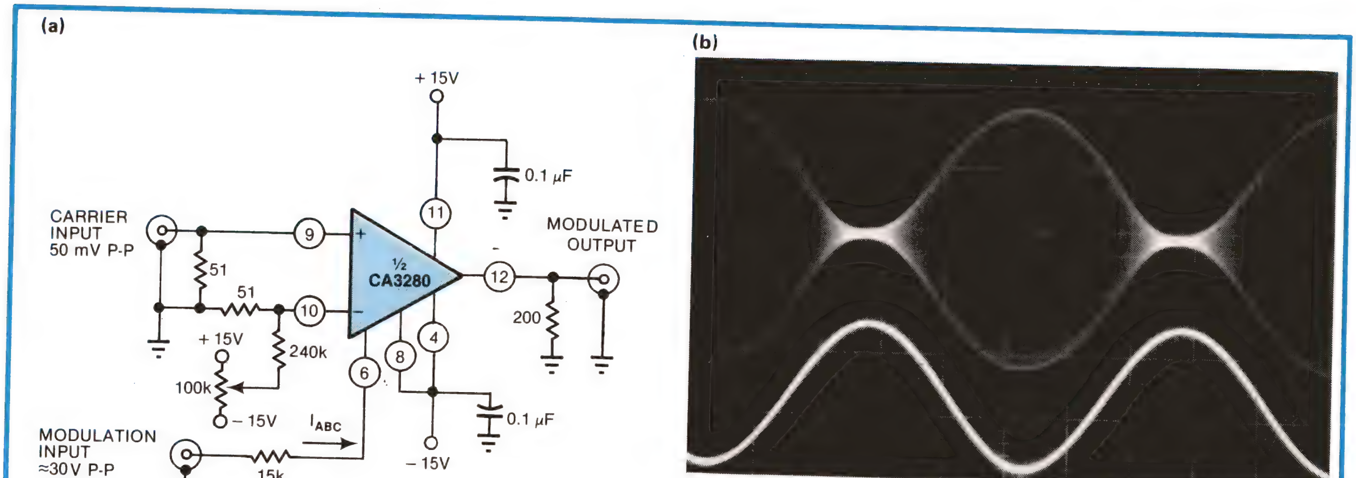


Fig 1—An amplitude modulator *(a) produces the upper waveform shown in* ***(b).*** *The top trace shows the modulated output of a 3-MHz carrier (20 mV/div); the lower one, a 10-kHz modulating signal (10V/div).*

and K_2=70Ω/mA. If both current-programming resistors connect to the same supply, the gain remains independent of the supply voltage. Decreasing the supply voltages or diode currents diminishes only the CA3280's large-signal-handling capabilities.

Make an inexpensive multiplier

One application that uses the linearization diodes to great advantage is depicted in **Fig 4:** Half of a CA3280 makes a temperature-compensated 4-quadrant multiplier. This type of multiplier, although not as accurate as many of the precision hybrid and monolithic units, does provide a low-cost circuit suitable for signal processing and wave shaping.

Operation of the multiplier depends on cancellation of the positive forward-current signal through R_f by an opposite-current signal from the CA3280. System transconductance is determined by R_1, R_2, R_{ABC} and R_D; R_f should equal the reciprocal of this number. Thus, only one value of programming current I_{ABC} can

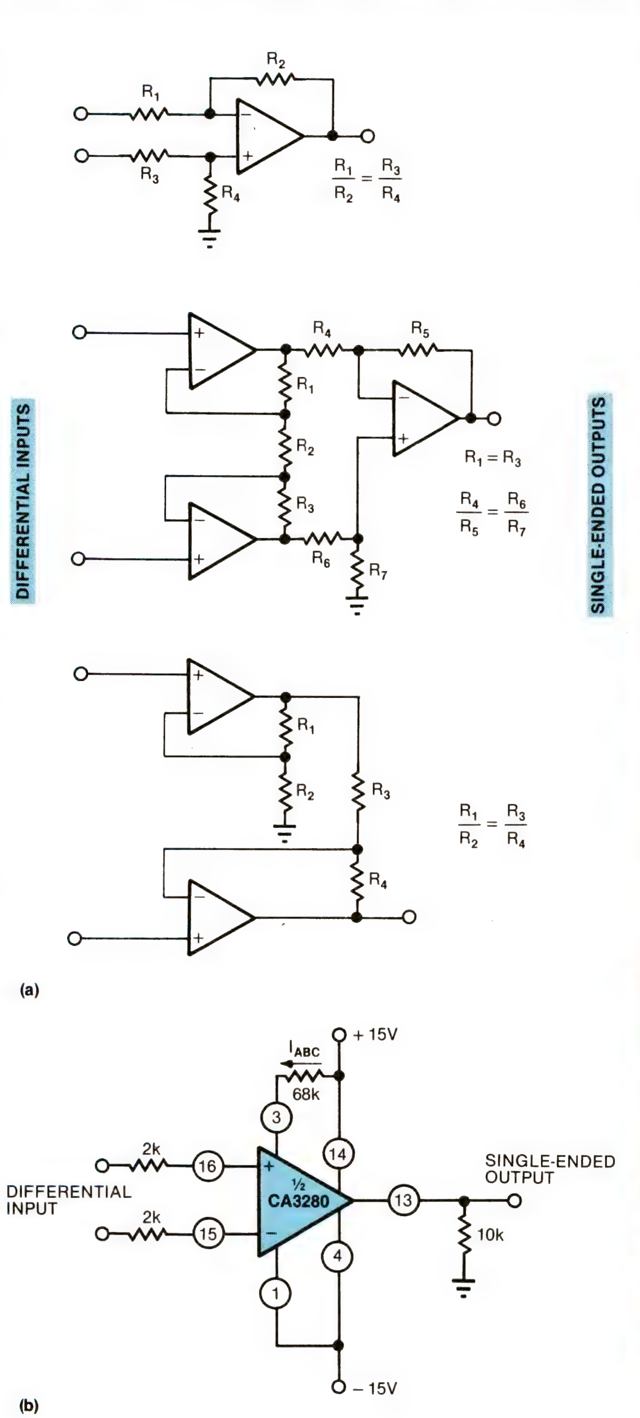


Fig 2—**The common schemes** *used for high-CMR differential amplification* **(a)** *are considerably simplified with a CA3280* **(b)**.

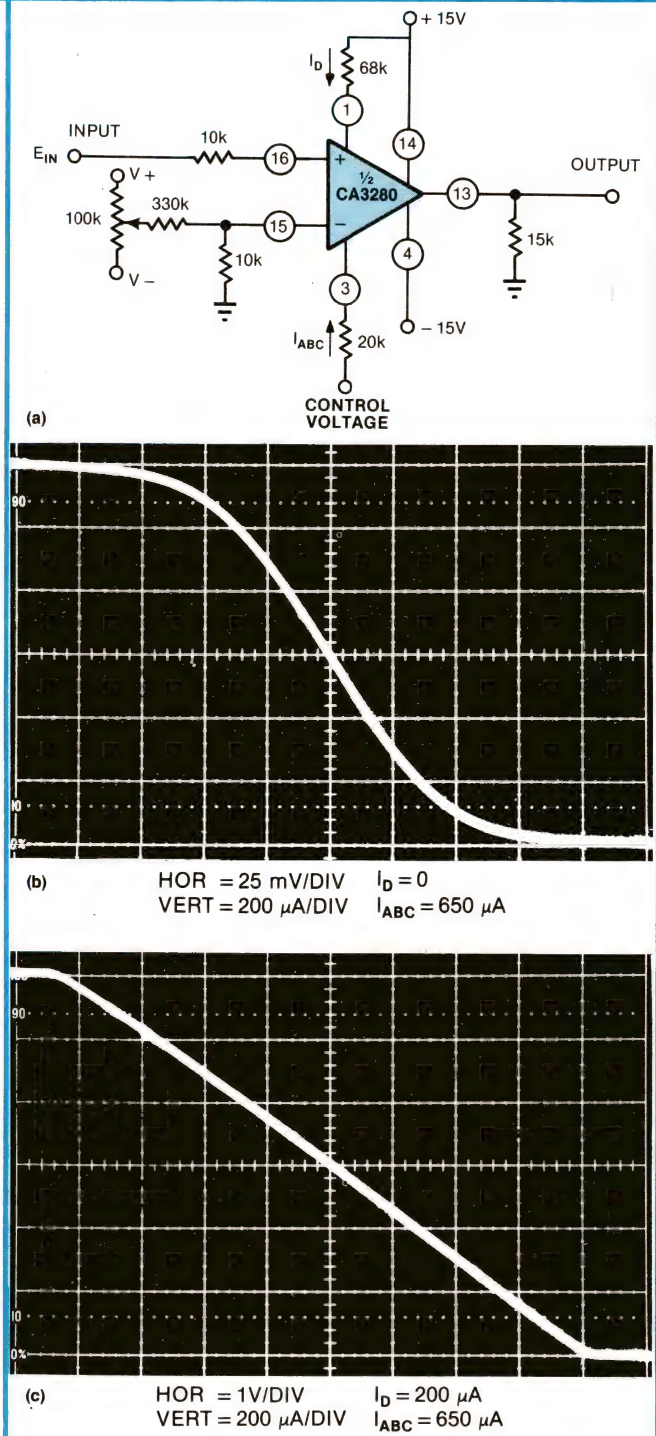


Fig 3—**Activating the linearization diodes (a)** *changes the CA3280's transfer characteristic from an s-curve* **(b)** *to a linear one* **(c)**.

Each half of a CA3280 can make a low-cost 4-quadrant multiplier

produce a canceling current when $V_Y=0$. If either or both of the inputs are 0, no output current will result. Depending on the value of V_Y, either the amplifier output current or the feedforward signal current dominates.

To obtain a differential-input 4-quadrant multiplier, you can use both OTAs in the CA3280 (**Fig 5**). This circuit is the functional equivalent of the one in **Fig 4** except that an amplifier replaces R_f. Only one linearization network is used because both inputs are connected in parallel.

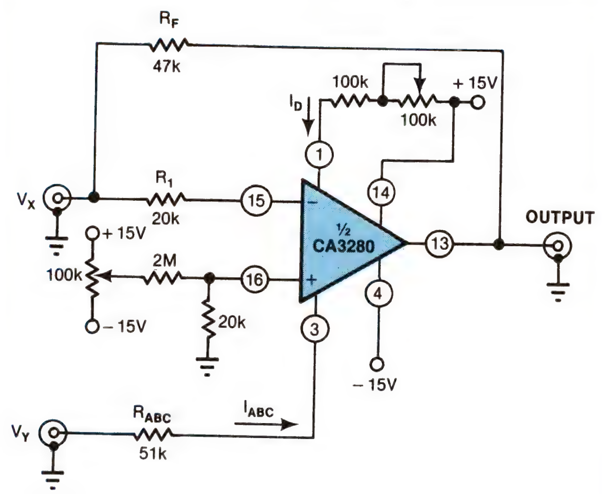


Fig 4—A single amplifier *in the CA3280 makes an inexpensive 4-quadrant multiplier with a current output.*

By increasing the input-resistor values, you can apply higher V_X input voltages. The V_Y signal must be symmetrical about ground and limited to the supply voltages.

Setup of either multiplier circuit is best accomplished with ac inputs. Once you have obtained the basic operation, you can use dc procedures to calibrate and set the scale factors.

Emitter outputs permit unique uses

One feature of the CA3280 has a bit more specialized application: The coupled emitters of each amplifier's differential input pair are available for user connection. One application for such emitter-coupled dual differential amplifiers is the triangle-to-sine converter diagrammed in **Fig 6.** Two 100k resistors connected between the differential amplifiers' emitters and V^+ reduce the current flow through the differential amp; this circuit permits the amplifier to fully cut off during peak input-signal excursions. With trimming, the circuit's harmonic distortion is about 0.37%; selective-feedback techniques can reduce this figure to 0.05%. As **Fig 6b** shows, most of the distortion stems from the discontinuity of the original triangle peaks.

Many comparators on one chip

The CA3280's programmability permits tailoring device speed/power characteristics for comparator applications. **Fig 7a** shows the device operating in a high-speed mode with delay times less than 80 nsec. The output signal is diode clamped at ECL or TTL

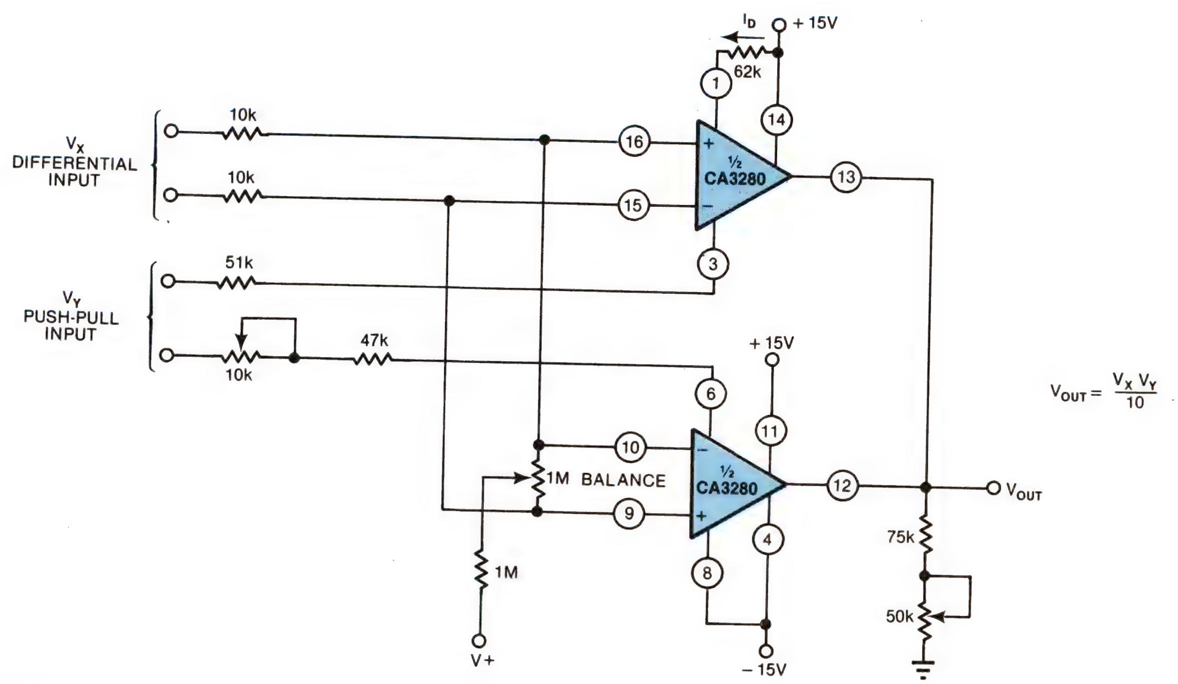
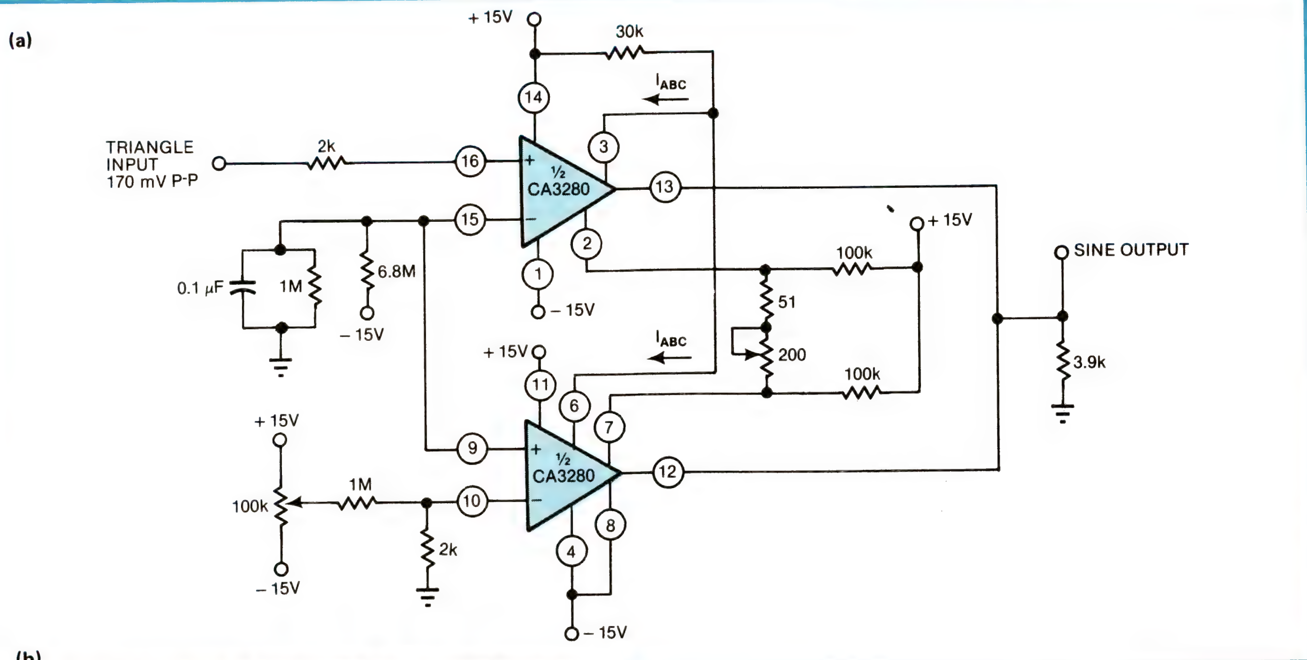


Fig 5—Using both halves *of a CA3280 in a 4-quadrant multiplier permits differential operation.*



(b)

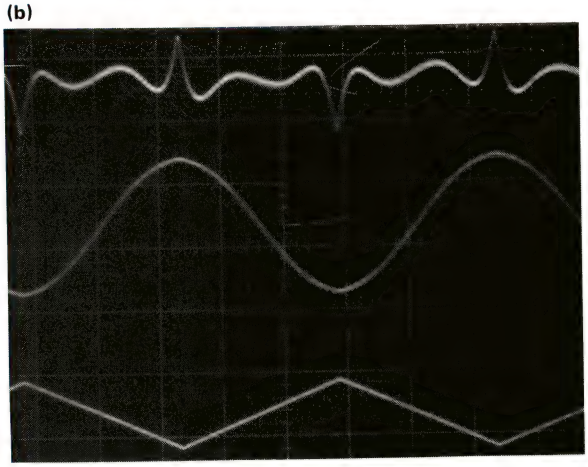


Fig 6—Coupling the emitters *of the OTA's differential input transistors permits construction of a triangle-to-sine converter with 0.37% THD* ***(a)****. You can see the residual distortion components in the top trace of* ***(b)****, along with the sine output (2V/div) and the input triangle wave (1 kHz).*

levels. Programming current is 3 mA, while the total supply current is 9 mA.

Fig 7b diagrams a micropower comparator. With a 5V supply, propagation delay is 120 µsec, while total power consumption is only 20 µW. **EDN**

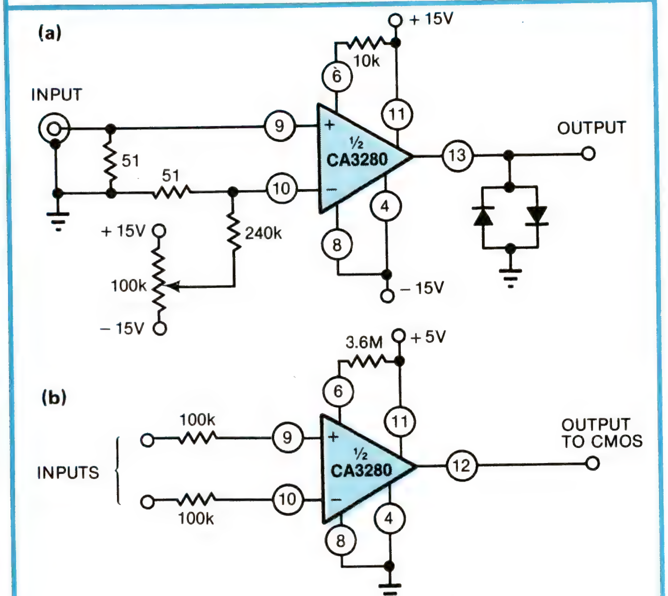
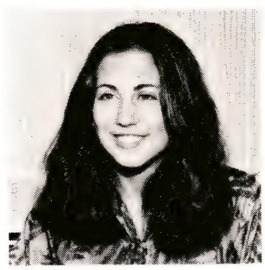


Fig 7—Programmability *permits the CA3280 to serve as a high-speed comparator* ***(a)*** *or a slower, 20-µW one* ***(b)****.*

Authors' biographies

Hal Wittlinger, engineering leader at RCA Corp's Solid State Div, Somerville, NJ, specializes in industrial linear-IC application engineering. He received his BSEE from Case Institute of Technology and has been with RCA for 23 yrs. Hal's avocation is flying.



Debra Nissman, also with RCA Solid State, is a market analyst handling new-product announcements and booking/billing reports. She received a BS in commerce at Rider College, and her hobbies include swimming, windsurfing, racketball, camping and travel.

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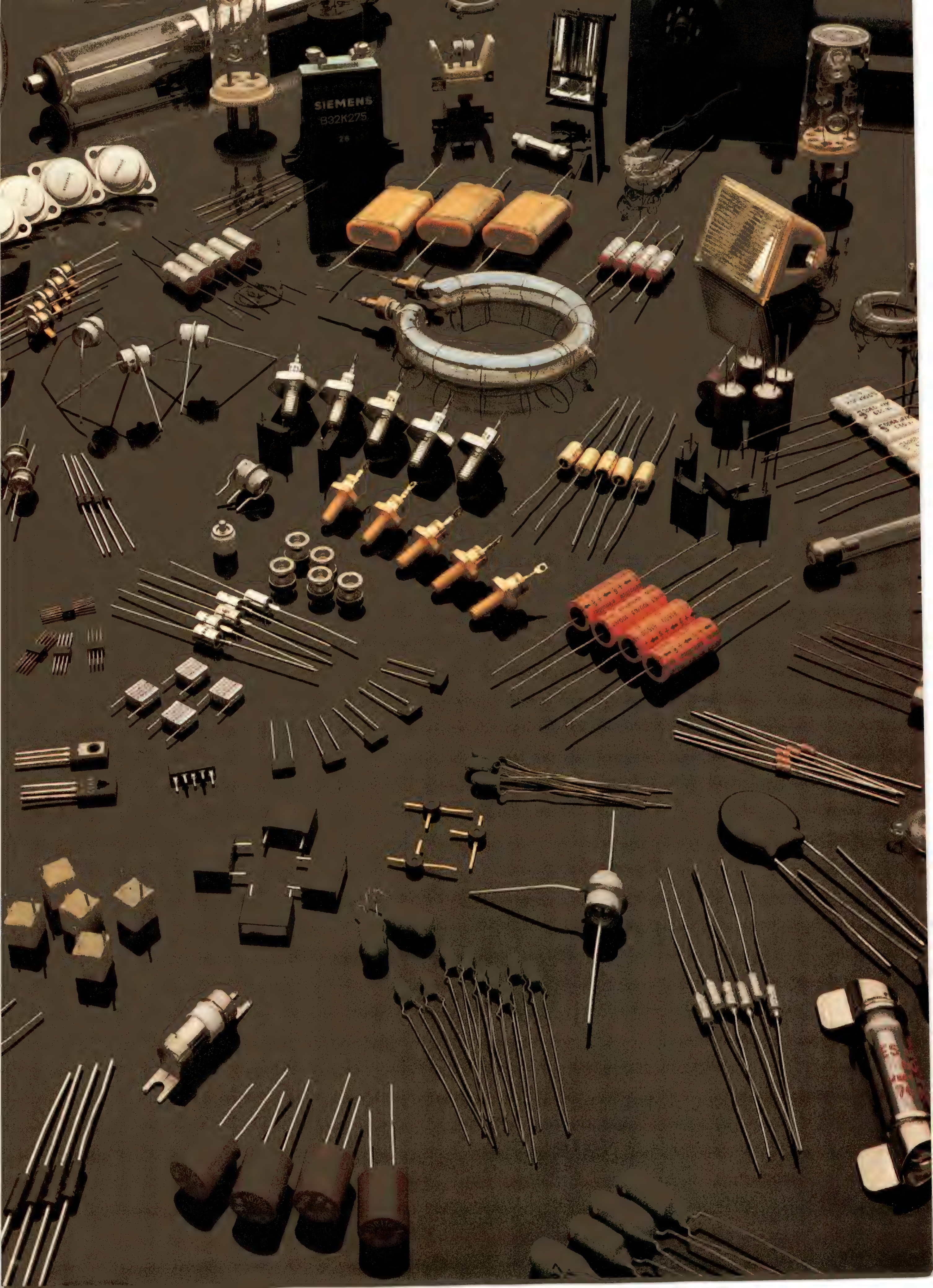
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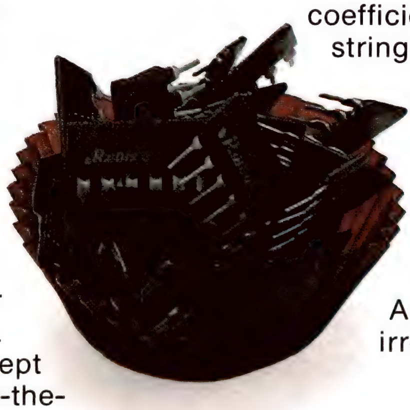

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Certain performance peculiarities are common to all single-chip, 3-terminal linear power regulators. A familiarity with the internal circuitry and construction of these ICs speeds the design process and improves the success of your application.

Robert C Dobkin, National Semiconductor Corp

Part 1 of this 2-part series (EDN, August 20, pgs 93-98) focused on regulator control ICs. This installment shifts attention to the power IC regulators that are quietly revolutionizing linear-power-supply design. Easy to use, these state-of-the-art devices feature on-chip protection circuitry that makes them almost blowout proof. Models currently available include both positive and negative versions with output-current capabilities exceeding 5A.

Figs 1 and **2** show the basic configurations for positive and negative fixed 3-terminal regulators, respectively. (The LM340 or 7800 Series typify the former; the LM320 or 7900 Series, the latter.) In both types, an error amplifier compares an on-chip reference with a fraction of the output and drives npn pass transistors; resistors R_4 and R_5 set the output voltage.

The reference employed can be either a zener diode or a band-gap type. Although many details of the construction and performance of these competing circuits were discussed in Part 1, the nature of power regulators dictates delving somewhat more deeply into thermal-design aspects. Specifically, with the larger number of components in a band-gap reference, IC designers must take extreme care with the chip layout to prevent temperature gradients—induced across the chip by variations in power dissipation—from severely degrading regulation.

New spec provides needed information

Thermal regulation, only now appearing on some regulator data sheets, is a parameter that measures the IC's sensitivity to variations in power dissipation. When the power in the pass transistor changes—either as the result of a change in load or in input voltage—the temperature gradients generated across the chip also fluctuate. If those portions of the reference that generate its positive and negative temperature coefficients do not experience exactly the same temperature variations, an output-voltage transient results. Typically, such a transient occurs 5 to 15 msec after the variation in power dissipation because it takes that long for temperature gradients to develop across the die.

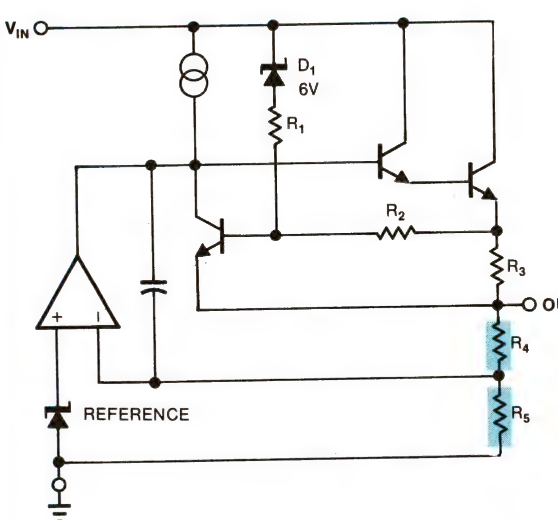

Fig 1—Positive-output fixed 3-terminal regulators *use this basic circuit configuration. Resistors R_4 and R_5 set the output voltage.*

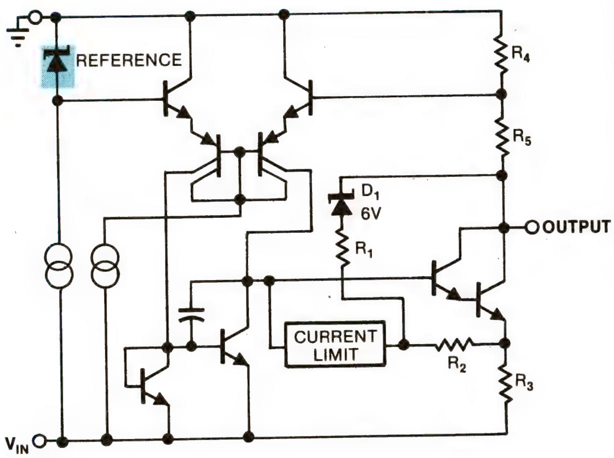

Fig 2—Negative-output fixed 3-terminal regulators, *like their positive cousins, use npn pass transistors. The voltage reference can be either a zener diode or band-gap type; the latter provides lower noise and better stability over time and temperature.*

A regulator's thermal limiting should be tested

Note that thermal regulation differs from, and is independent of, a power regulator's temperature coefficient; the latter specification measures the change in reference voltage with temperature when all parts of the reference circuitry reach thermal equilibrium.

Generally, a poorly designed or manufactured power regulator will exhibit a thermal regulation of about a 0.1% output change per watt change in power dissipation; a good device, 0.002%/W. Consider **Figs 3, 4** and **5**, for example, which document actual variations in thermal regulation for three LM317-type 3-terminal regulators. Obviously, the performance characteristics shown differ vastly, and use of the inferior devices could adversely affect critical applications. Thus, responsible manufacturers will probably make thermal-regulation specifications mandatory on future IC-power-regulator data sheets.

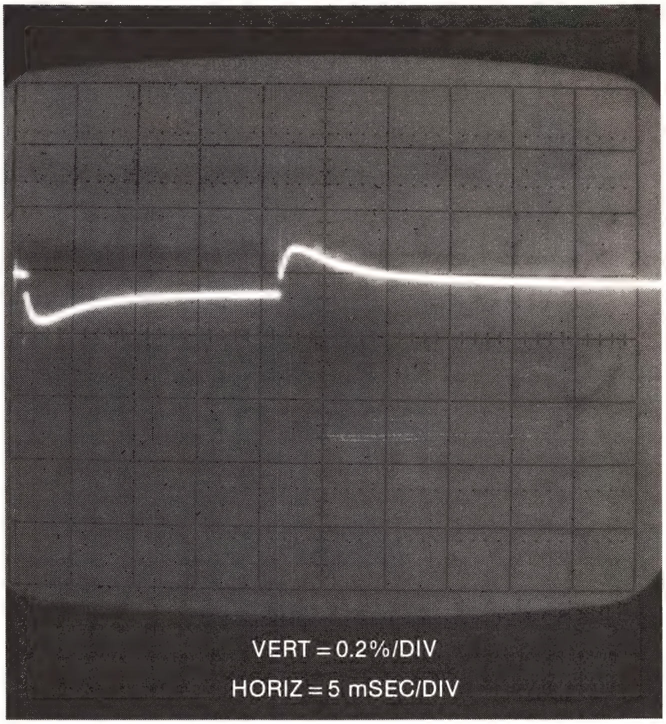

Fig 3—The thermal response *of a typical National Semiconductor LM317 to a 10W power change indicates the performance attainable with proper chip layout and manufacturing techniques. Unfortunately, not all manufacturers' data sheets provide information on this specification.*

When fixed regulators just won't do...

Designers now have alternatives to 3-terminal fixed regulators: the LM317 adjustable positive regulator and the LM337 adjustable negative version. Both power devices are configured as floating regulators with no ground terminal and require two external resistors to set the output voltage **(Fig 6).** But in addition to adjustability, these regulators also feature improved protection circuitry: The current-limit point remains constant with temperature and doesn't decrease to zero at high input-to-output voltage differentials. Moreover, the thermal-limiting circuitry in both ICs remains functional even when the adjustment terminal is disconnected.

Referring to the basic configuration shown in **Fig 6,** observe that the op amp forces the output to 1.2V above the potential at the adjustment terminal. This action maintains a constant 1.2V across R_3 (nominally 240Ω) and therefore a constant 5 mA through it. The 5 mA then flows through R_4 to ground, boosting the voltage at the adjustment terminal and at the output. Only 50 μA flows from the adjustment terminal due to the 1.2V band-gap reference—a small value that can usually be ignored when compared with 5 mA.

With no ground terminal per se, all of the adjustable voltage regulator's quiescent current flows into its output. Thus, to ensure regulation with no external load, the current in the adjustment resistors should be higher than the maximum quiescent supply current.

Design hints that apply to all regulator types

Whether fixed or adjustable, the input voltage to 3-terminal regulators must be maintained at least 3V higher than the output. However, input/output differentials greater than 7V (for fixed types) or 15V (for adjustable units) activate the safe-area protection, decreasing the current limit and reducing the maximum output current below the nominal rated value. It's an inexpensive solution, then, to specify heat sinks that can just handle the regulators' maximum operating dissipations at maximum operating ambients; no safety margins are needed because thermal-shutdown circuits will protect the devices under overload conditions.

Proper bypass capacitors are critically important to prevent oscillations in IC-power-regulator applications. At the input, values of 0.2 μF or greater are recommended. Although device-to-device tolerance to input bypassing varies widely, a conservative design generally includes a 1-μF solid-tantalum or 25-μF electrolytic capacitor connected physically close to the regulator.

As noted in Part 1 of this series, an IC regulator, like any feedback amplifier, exhibits a range of output capacitive loading where stability is degraded: Although the circuit might not oscillate, it can exhibit poor transient response or ringing. Good design practice therefore dictates using large output capacitors (1 μF or larger)—again mounted within a few inches of the IC—to swamp out these effects and ensure stability. This recommendation holds even though positive regulators are designed to be stable without any external output capacitor (negative regulators must have one).

Protection circuitry—know your limits

Although 3-terminal power regulators are protected against short circuits, designers should ensure that the current the IC draws when in limit-mode operation doesn't overload the input rectifiers or transformer.

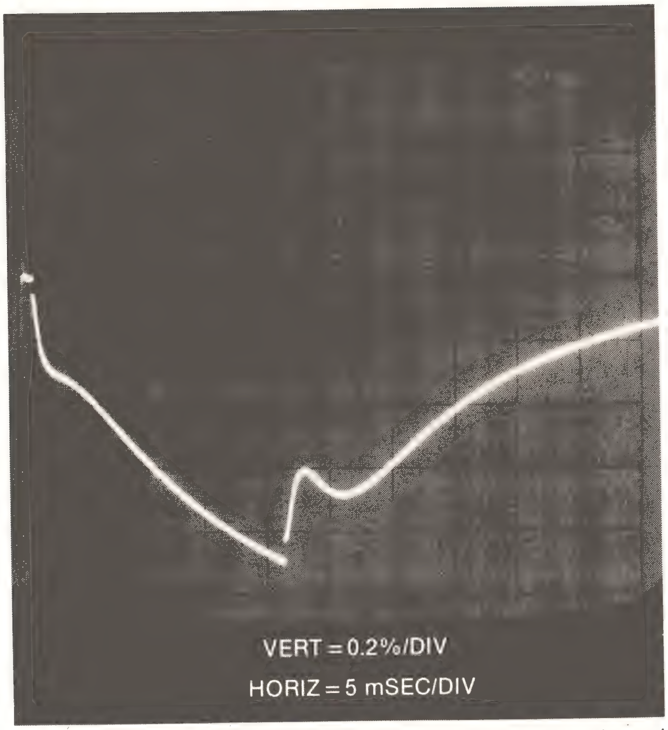

Fig 4—Voids under the die *have severely degraded the thermal regulation of this reject LM317.*

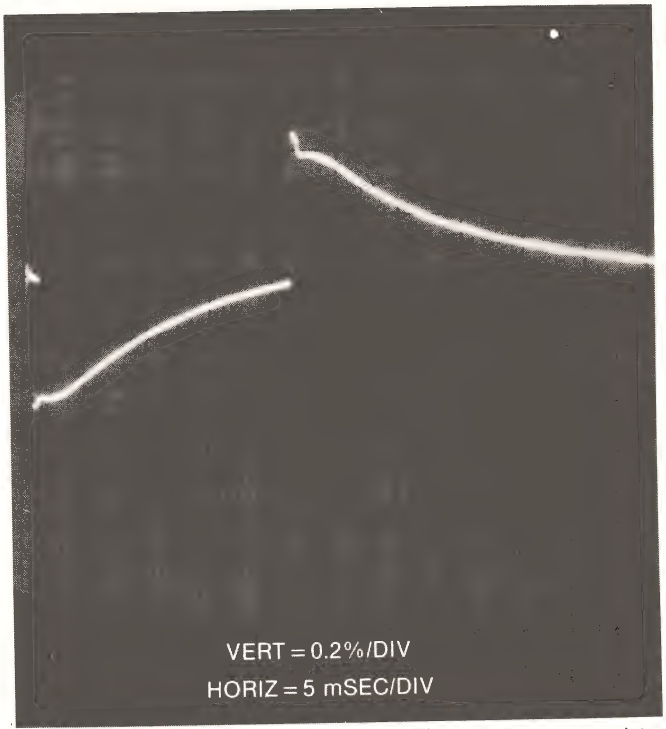

Fig 5—The different layout *of a competitor's 317-type regulator produced this thermal response to a 10W pulse. Electrical regulation causes the fast-response portion of the trace; it typically produces a transient within 50 μsec of a line or load change.*

Semiconductor manufacturers usually set the on-chip current limit so that the device can still provide rated output current at maximum operating temperatures, given worst-case production variations. Thus, older types of regulators (LM309, LM340, LM7800, etc) have a current limit of up to three times their rated output because the turn-on voltage of a transistor's emitter-base junction sets the limit point. (The temperature coefficient of this junction, combined with the temperature coefficient of the internal resistors, furnishes a −0.5%/°C limit-point TC. Also, because power regulators must operate and provide rated current at 150°C, the 25°C current limit is 120% higher than typical; production variations add another ±20% to the initial tolerance. The net result? A typical 1A part can exhibit a current limit of 3A at 25°C.)

One way to design around this problem (aside from using fuses) has already been described: Specify a heat sink just adequate for normal operation. Then, under overload conditions, the regulator and its heat sink warm up to the thermal shutdown temperature, the device shuts down, and loading on the input is reduced.

Newer power-regulator ICs feature improved current-limiting circuitry. Devices such as the LM117 adjustable regulator, the LM138 5A regulator and the LM137 negative regulator hold the current-limit point within ±10% over the full −55 to +150°C operating range. A unit rated for 1.5A output typically exhibits a 2.2A current limit, greatly easing the problem of input overloads. **Fig 7** shows the current-limit characteristics of several power-regulator types.

Be aware, however, that many older-model 3-terminal IC regulators can oscillate when operating in the current-limit mode. The oscillation doesn't hurt the regulator, but it might cause a system problem. If so, no single solution will eliminate it because a large variability exists among regulator types and even among similar types from different manufacturers. Generally, either a solid-tantalum input capacitor or a solid-tantalum unit in series with 5 to 10Ω effects a cure; if one method doesn't work, try the other.

Do start-up problems turn your circuit off?

Current-limit circuitry can also cause start-up problems. At high input/output differentials, the safe-area protection decreases the current limit: In most regulators the decrease is linear, with the output current dropping to zero at input/output differentials of about 30V. Usually such protection creates no difficulty because the regulator's output increases as the input voltage increases when the device is powered up.

But consider, for example, a fixed 3-terminal regulator running with 30V input and 15V output. If its output is momentarily shorted, the input/output differential increases to 30V, and the available output current becomes zero. Then, when the short is removed, the output of the regulator stays at zero. Of course, if the input voltage is turned off and then on again, the regulator returns to normal operation. (This scenario doesn't apply to adjustable IC regulators; they feature a special safe-area protection circuit that maintains a finite output current even at a 40V differential.)

The start-up problem just described is particularly load dependent. Loads connected to a separate negative supply or to constant-current devices cause the worst difficulties, but pilot lights constitute

Does the spec sheet show thermal regulation?

another, usually overlooked, problem load: Incandescent bulbs draw eight times as much current when cold as when operating. Thus, they can severely add to a regulator's load and could prevent turn-on.

Solutions? Use an adjustable-type device, or bypass the regulator with a resistor from input to output to supply start-up load current. Such resistor bypassing won't degrade regulation if, under the worst-case conditions of maximum input voltage and minimum load current, the regulator still delivers output current rather than absorbs current from the resistor.

A particularly serious start-up problem occurs when a negative supply loads a fixed positive regulator. First, the problem of safe-area protection, previously described, arises. Second, the regulator cannot supply much output current when its output pin is driven more negative than its ground pin. Even with the low input voltages, some positive regulators will not start when loaded by 50 mA to a negative supply. But clamping the output to the ground with a germanium or Schottky diode usually solves this problem. Negative fixed regulators, on the other hand, use different internal circuitry, so they can readily handle loads connected to a positive supply.

Thermal protection is effective, *if* it works

Without thermal-overload protection, a 3-terminal regulator's other protection circuitry can only withstand short-term overloads. With it, the device won't be destroyed by indefinite short circuits, overloads at high temperatures or inadequate heat sinking. But thermal limiting does pose one problem: testing.

You can easily measure a regulator's short-circuit and safe-area protection electrically. However, for thermal limiting to operate properly, not only must the IC's electrical circuitry function, but the chip must also be well attached to its package and exhibit no hot spots. Therefore, virtually the only way to ensure that thermal protection works is to power the regulator with maximum input voltage, short the output and let the device cook. Then, if the IC remains functional after 5 min (or more), the thermal limit has operated properly.

Of course, this type of testing is time consuming and expensive for the manufacturer, so it isn't always performed. Some regulators, such as the LM117, LM137, LM120 and LM123, receive an electrical burn-in in thermal shutdown as part of their normal manufacturing process. The procedure does double duty: It ensures that the thermal limiting works, while also reducing infant mortality.

Thus, if your power supply is likely to experience overloads that cause the IC regulator to thermally limit, you should either test the device's operation in this mode yourself, ask the manufacturer to do it or—to be safe—do both.

Diodes protect against capacitor discharge

Despite all their protection circuitry, 3-terminal regulators can still be destroyed. Input overvoltage, for example, will fry the chip, breaking down the transistor junctions. Fortunately, high-voltage transients are usually filtered by the capacitors in most power supplies. But it's important to recognize that filter capacitors are not a cure-all; true, they can eliminate many transients, but they can also cause some.

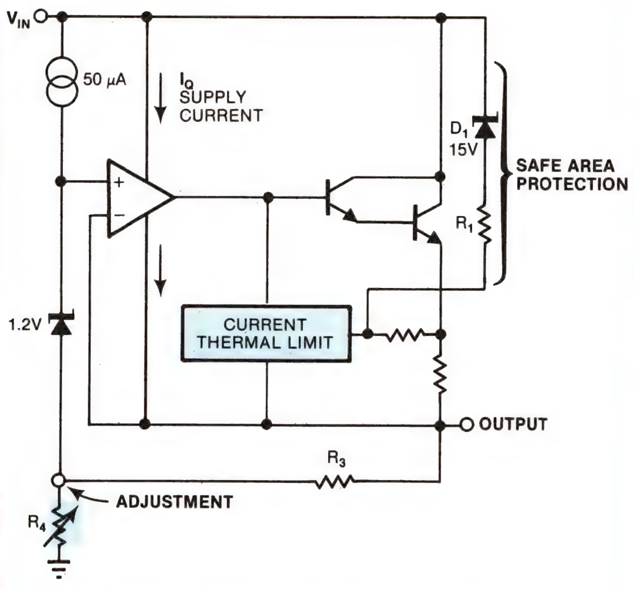

Fig 6—External resistors set the output level *of the LM317 (positive) and LM337 (negative) adjustable regulators. Both devices feature thermal-limit circuitry that remains functional with the adjustment terminal disconnected.*

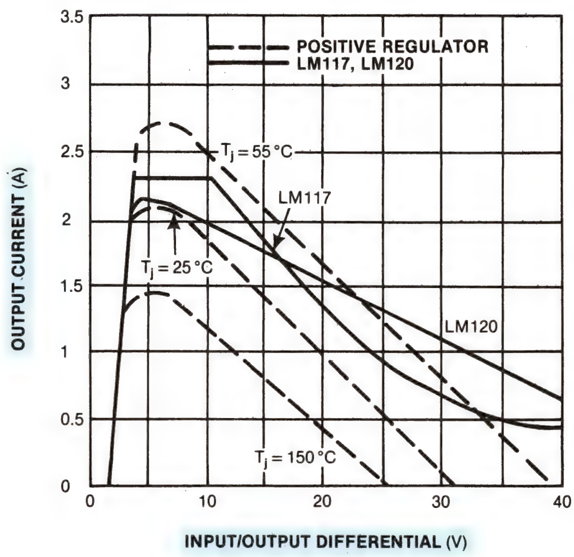

Fig 7—Current-limit characteristics *of IC power regulators vary with temperature. The change is most pronounced in older IC designs that use a transistor's emitter-base turn-on voltage to set the limit point.*

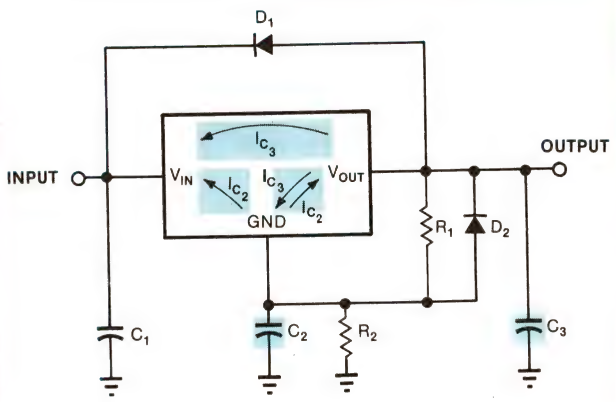

Fig 8—Discharge paths *of external capacitors can destroy an IC regulator under abnormal conditions unless designers exercise care and specify protection diodes.*

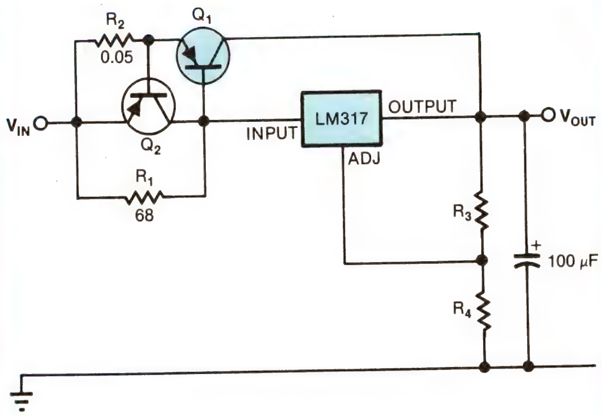

Fig 9—Adding a pnp boost transistor *can increase the output of an adjustable 3-terminal regulator to above 10A.*

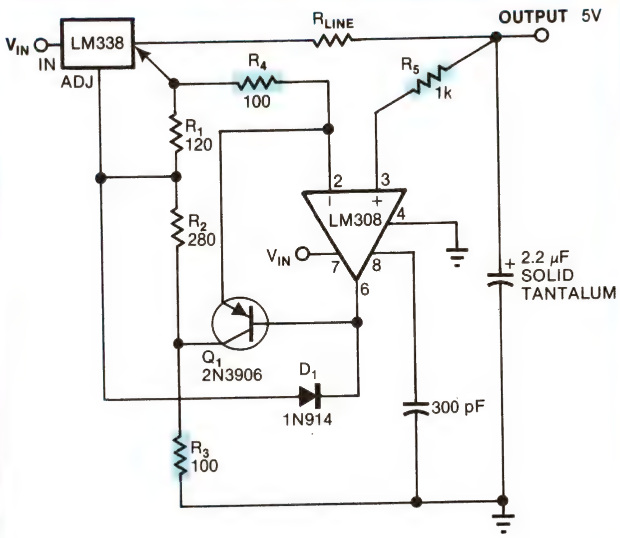

Fig 10—A 1V drop *between the high-current regulator and its load causes 10 mA to flow in R_4. This current, flowing through R_3, increases the voltage at the adjustment pin by 1V, keeping the load voltage at its proper level. Diode D_1 prevents a possible latch-up situation, while R_5 protects against an open output line. The output capacitor is needed for stability.*

Fig 8 shows the discharge path for different capacitors used with a positive regulator. Input capacitor C_1 won't cause a problem under any conditions. However, capacitance on the ground pin (or adjustment pin, in the case of adjustable regulators) is a different story. If the output is shorted, C_2 discharges through the ground pin, destroying the IC unless a reverse-biased diode (D_2) diverts the current. Another situation: If the input is shorted, C_3 can discharge through the output pin, again damaging the regulator; diode D_1 prevents such damage. And with both D_1 and D_2 in the circuit, C_2 safely discharges through both diodes when the input is shorted.

In general, protective diodes should be used in all 3-terminal positive-regulator circuits. At higher output voltages, they become particularly important because the energy stored in the capacitors becomes significant. (Negative regulators and the LM117 have an internal diode in parallel with D_1 from output to input; this provision eliminates the need for an external diode if the output capacitor is less than 25 µF.)

Another potentially damaging transient condition is caused by improper current flow into the regulator. Applying inputs of the incorrect polarity or driving current into the output (such as might occur when the 5 and 15V supplies are shorted together) can force high currents through small-area junctions in the IC, destroying them. Unfortunately, improper polarities can be applied accidentally in many normal operating situations, and the transient condition that can result is often gone before it is recognized.

Recommended design practices? Polarized connectors, covers on critical wiring and similar protective measures. These approaches aren't cure-alls, though; there aren't any for this problem.

A third transient condition can prove fatal to a 3-terminal regulator: a momentary loss of the connection to the IC's ground pin. The loss of contact charges the output capacitor to the unregulated input-voltage level minus a 1 to 2V drop across the regulator. When the ground is reconnected, output capacitor C_3 discharges through the regulator's output to the ground pin, destroying the chip. In most cases, this problem occurs when someone plugs a regulator IC (or circuit board) into a powered system in such a way that the input pin makes connection before the ground pin.

The best cure for this problem? A properly designed connector configuration. For example, use two ground pins to ensure that the ground connection is made before any others. Electrical protection, however, is cumbersome: One scheme makes D_2 a power zener with a breakdown voltage 1 to 2V above the regulator voltage, then includes a 10 to 50Ω resistor in the ground lead to limit the current.

Need more power? Proceed with caution

Boosting the output current of IC regulators isn't necessarily the simple, trouble-free task it might first appear. **Fig 9** shows how designers commonly achieve output currents of 10A and more: They add a pnp boost

Filter capacitors also create transients

transistor around the 3-terminal power regulator. As current is drawn, the voltage drop across R_1 turns Q_1 ON, supplying current to the output. Q_1's gain necessitates additional frequency compensation, which the 100-μF output capacitor supplies. Note that Q_2, the current-limiting transistor, must also be a power device because it absorbs the regulator's output current in limit operation.

Now the warnings: Mounting the IC regulator on the same heat sink as Q_1 can provide some measure of thermal-overload protection, but it isn't always effective. Another, more insidious, problem is caused by the power pnp's slow transient response: When a heavy load (or a short) is removed, stored base charge can keep the pnp turned ON, thus forcing the regulator's output positive and creating a large transient that can damage many types of loads. Moreover, if a fixed regulator is used, the current driven into the output can destroy it. (In **Fig 9**'s circuit, R_4 limits the current driven into the adjustable regulator.)

Long leads and high loads: a critical combination

With higher current IC regulators, such as the 5A Model LM338, line drops cannot be ignored: With 5A output currents, even 0.01Ω in the wiring to the load can limit regulation to 1% at 5V output. To achieve a factor-of-two improvement in regulation, you can return the ground side of the adjustment resistors to the load. In systems with many connectors, however, this technique might not suffice, and the method of remote sensing shown in **Fig 10** is recommended.

In **Fig 10**'s circuit, the op amp senses line drops and compensates for them; any voltage across the line resistance is forced to appear across R_4 by current flow in Q_1. Because the currents in Q_1's emitter and collector are almost equal, the current flowing in R_4 is essentially the same as that flowing in R_3. This current in turn increases the voltage at the power regulator's adjustment terminal to keep the output voltage constant. Furthermore, by adjusting R_4, you can even make regulation positive to compensate for additional (unsensed) line drops. Exercise caution, however, because more than 100 mV of positive regulation could cause oscillation problems.

Although **Fig 10**'s circuit might seem complicated compared with a 4-terminal-type regulator, the costs of the two approaches are about equal. In fact, the nonstandard package of the 4-terminal device and its nonstandard heat-sink configuration can actually increase a system's total cost more than the addition of a $0.50 op amp. **EDN**

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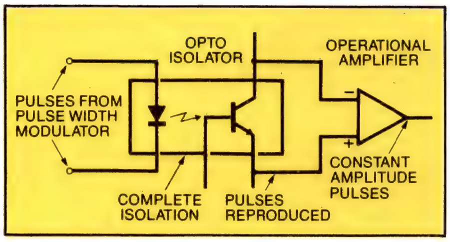

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Interlaced video displays utilize low-cost CRT controllers

Offering an alternative to traditional raster-scan methods, interlaced raster-scan displays employ slower, alternating-sweep refresh rates that require less expensive control circuitry.

Brian Cayton, Standard Microsystems Corp

As the demand for greater CRT display densities continues to increase—and the screen-refresh frequencies necessary to drive such systems thus rise—interlaced display formats grow more attractive. Interlacing techniques allow you to create inexpensive displays that formerly would have required costly custom controllers.

Most of today's video-display systems utilize a simple noninterlaced raster-scan technique. In this type of display **(Fig 1),** the electron beam scans across and down the CRT, painting zig-zag raster lines on the screen. The system displays data—in dot-matrix

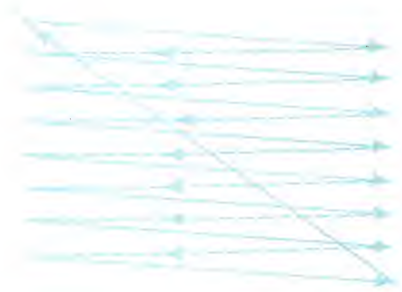
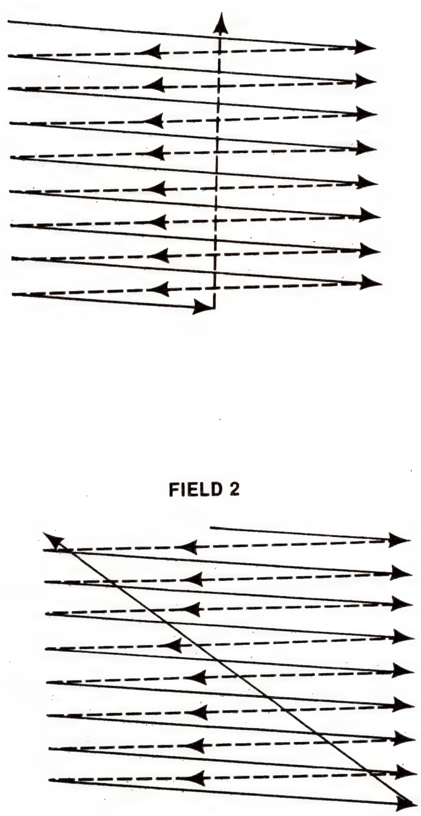


Fig 1—Traditional noninterlaced raster-scan formats *cover the entire screen area with one sweep sequence.*

FIELD 1

FIELD 2



COMBINED FRAME

Fig 2—Interlaced scan formats *sweep alternating areas on two passes, producing two interleaved fields that combine to cover the entire CRT screen.*

Noninterlaced-display densities hit high-frequency constraints

character form—by modulating the intensity of the beam. The raster covers the entire portion of the screen on which data can appear, breaking it up into a discrete number of lines that equals the horizontal sweep rate divided by the vertical sweep rate. In most standard monitors, this number equates to 15,720 Hz divided by 60 Hz—262 lines.

Some of these lines are lost, however, because of the finite time required for the electron beam to retrace from the bottom of the screen to the top. To allow for this vertical retrace time—as well as for upper and lower margins—video systems typically blank 21 or 22 lines, leaving 240 raster lines for actual data. How many characters this number of raster lines represents depends on the character block utilized.

Currently the most popular character format, the 7×9 dot matrix provides reasonable character resolution without using an excessive number of dots. In order to furnish horizontal spacing between characters, systems normally add one or two dots, increasing the character-block width to eight or nine dots. To allow for vertical spacing and lower-case descenders (such as the tail on a lower-case y), designers can allocate 12 vertical dots (scan lines). This vertical parameter permits displays of 240÷12=20 rows of data.

The number of characters you can display in one of these rows depends on the video frequency employed. For example, if the horizontal frequency is 15,720 Hz, a display of 100 8-dot-wide characters requires a video frequency of 15,720×8×100=12.576 MHz. In actual use, the system would blank 20% of these characters for retrace and side margins, so an 80-character display results.

What if you desire more rows of data? The most obvious way to increase the number of data rows is to increase the horizontal frequency. This increase, however, can necessitate the use of nonstandard deflection components as well as special circuitry to increase video frequency—all resulting in increased cost.

Interlaced approach utilizes two scan fields

Alternatively, you can utilize interlaced deflection to double the number of scan lines provided with no component changes (**Fig 2**). An interlaced-raster system employs two sweep fields, with the vertical sync positioned so that when the beam reaches the middle of the first field's last line, it retraces not back to the top left corner, but rather to the middle of the top line. Similarly, when the beam reaches the end of the second field, it retraces to the top left corner. Thus, the second field is painted between the lines of the first; the two fields combine to make up the displayed frame.

This interlacing technique allows you to display up to 40 rows of data using the components of the earlier example. As an added benefit, because the horizontal frequency is not increased, the video rate remains the same as for a 20-row display—thus holding down the

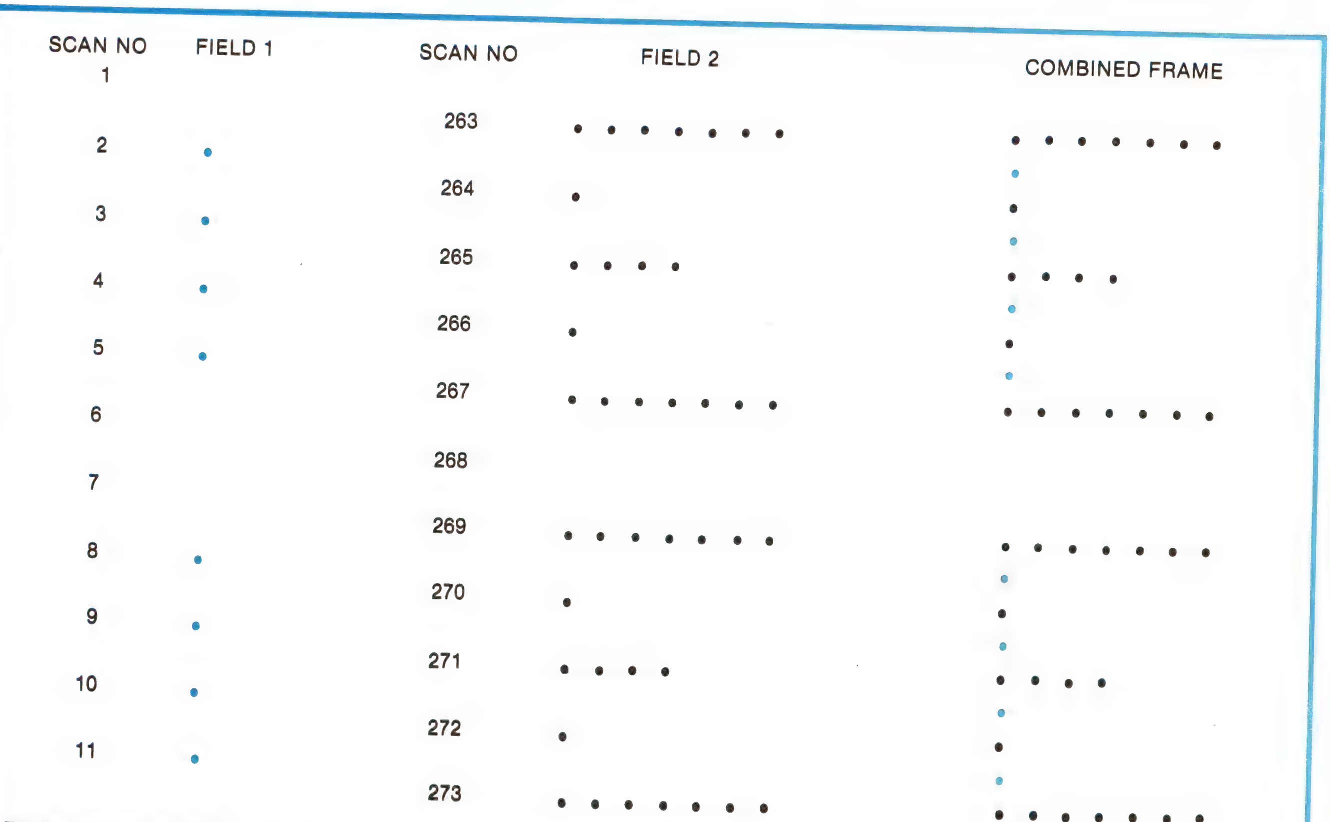


Fig 3—Interlaced displays *that generate an even number of scan lines per row can—in characters such as a capital E—encounter differing amounts of data in their two scan fields.*

cost of the video circuitry.

Interlaced formats can produce some pitfalls, but they aren't difficult to avoid. The most well-known of these potential problems is the flicker resulting from refreshing each line 30 times per second rather than 60.

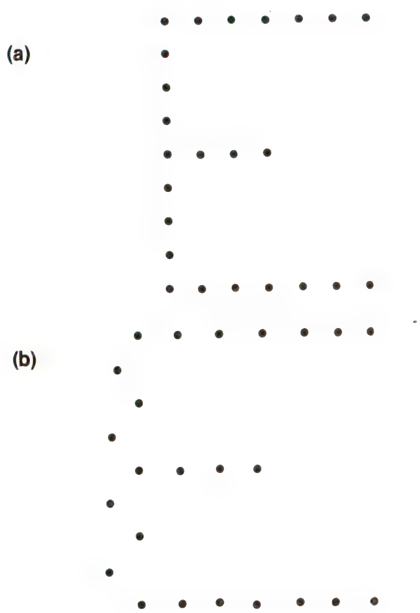


Fig 4—Scanning disproportionate amounts of data *in fields 1 and 2 can—if uncorrected—cause an interlaced display to distort characters. A normal capital E* **(a)**, *for example, might appear with improperly spaced dots* **(b)**.

You can easily prevent this flicker, however, by choosing a CRT with a long-persistence phosphor such as P39.

Somewhat more subtle problems can arise as a result of differences in the information in the first and second fields. **Fig 3,** for example, illustrates how an interlaced display that generates an even number of scan lines per row paints the letter E on its two top rows. Field 2 contains virtually all of the data; field 1, virtually none. As a result, if the system displays a large number of letter Es (or similar characters), the beam current of the CRT will increase during field 2, lowering the monitor's high voltage. This lower voltage will in turn cause an increase in the CRT's deflection sensitivity during field 2 and, correspondingly, produce wider lines and increased dot spacing **(Fig 4).**

You can prevent this problem by programming an odd number of scan lines per data row **(Fig 5)**—a scheme that averages the display load over two rows. Each field thus receives a balanced beam current.

One last pitfall to watch out for: Some CRT monitors are designed strictly for noninterlaced operation and thus cannot perform correctly in the interlaced mode. If you have doubts about a specific monitor, contact its manufacturer.

To compare interlaced and noninterlaced modes from a design standpoint, consider an actual CRT control circuit **(Fig 6).** The display format provides 80 characters per row in 25 rows of displayed data. For maximum legibility, this circuit displays a 128-

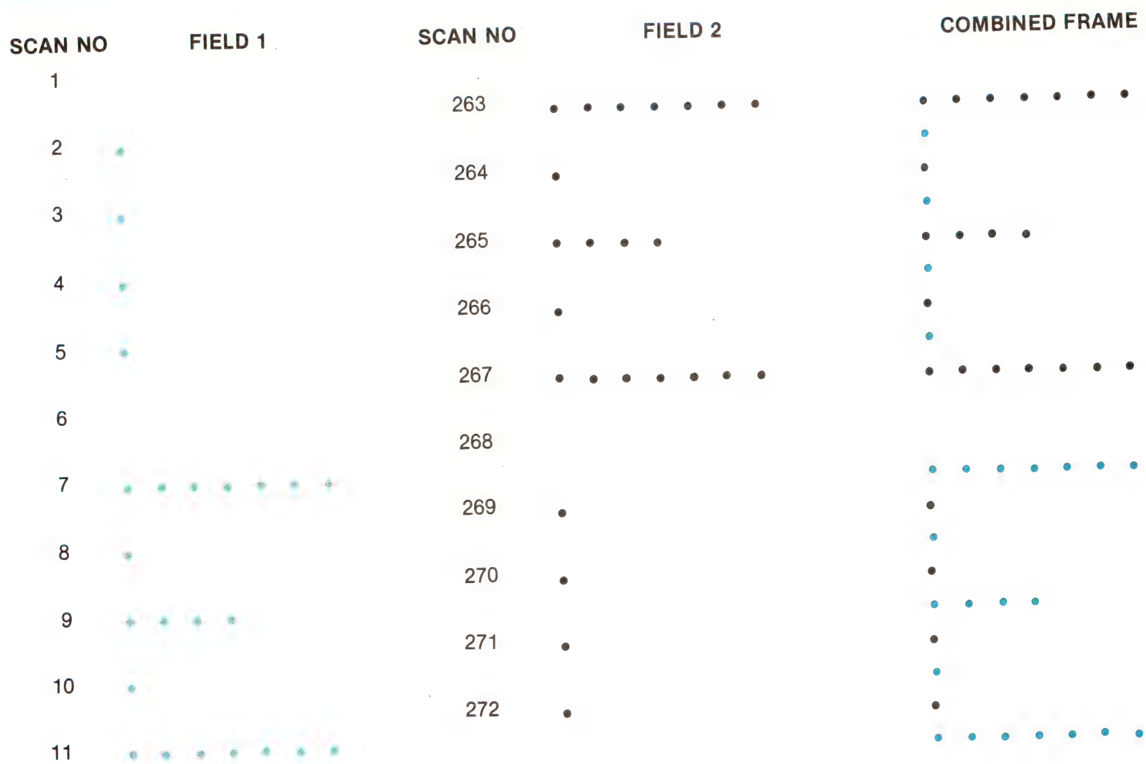


Fig 5—Generating an odd number of scan lines per row *prevents the kind of distortion shown in* **Fig 4.**

Interlaced CRT display formats refresh at half the usual rate

character 7×11 dot matrix, producing 7×9-dot characters with descenders. To provide spacing between characters horizontally and vertically, the format allows for a block nine dots wide and 13 dots high.

The circuit design shown in **Fig 6** is actually the same for both interlaced and noninterlaced designs. A 32×8 PROM (IC_7) controls the format; NAND gates IC_{1A} and IC_{1B} provide the video clock, which IC_4 then divides to produce the word clock. The CRT controller (IC_3) provides sync pulses, blanking timing and refresh-memory addressing. Furnishing direct attributes control, the CRT 8002 display controller converts ASCII data from RAM into either alphanumeric or graphics characters. It outputs serialized video data, which is buffered by IC_{11} to drive a monitor.

Component values depend on scanning speed

But while the basic circuit is the same for both interlaced and noninterlaced systems, the speed at which the components must operate—and thus the quality of components required—differs greatly.

The number of raster lines required in this application, for example, equals the number of rows times the number of scan lines per row, plus the number of lines required for retrace (usually 20 or 21). In this case, $n=(25\times13)+21=346$. To achieve this number of raster lines in noninterlaced display, the horizontal scan frequency must equal $346\times60=20{,}760$ Hz. You can obtain a unit with this scan frequency, but it is nonstandard and costs a premium price.

Another parameter, the character rate (F_{CC}), equals

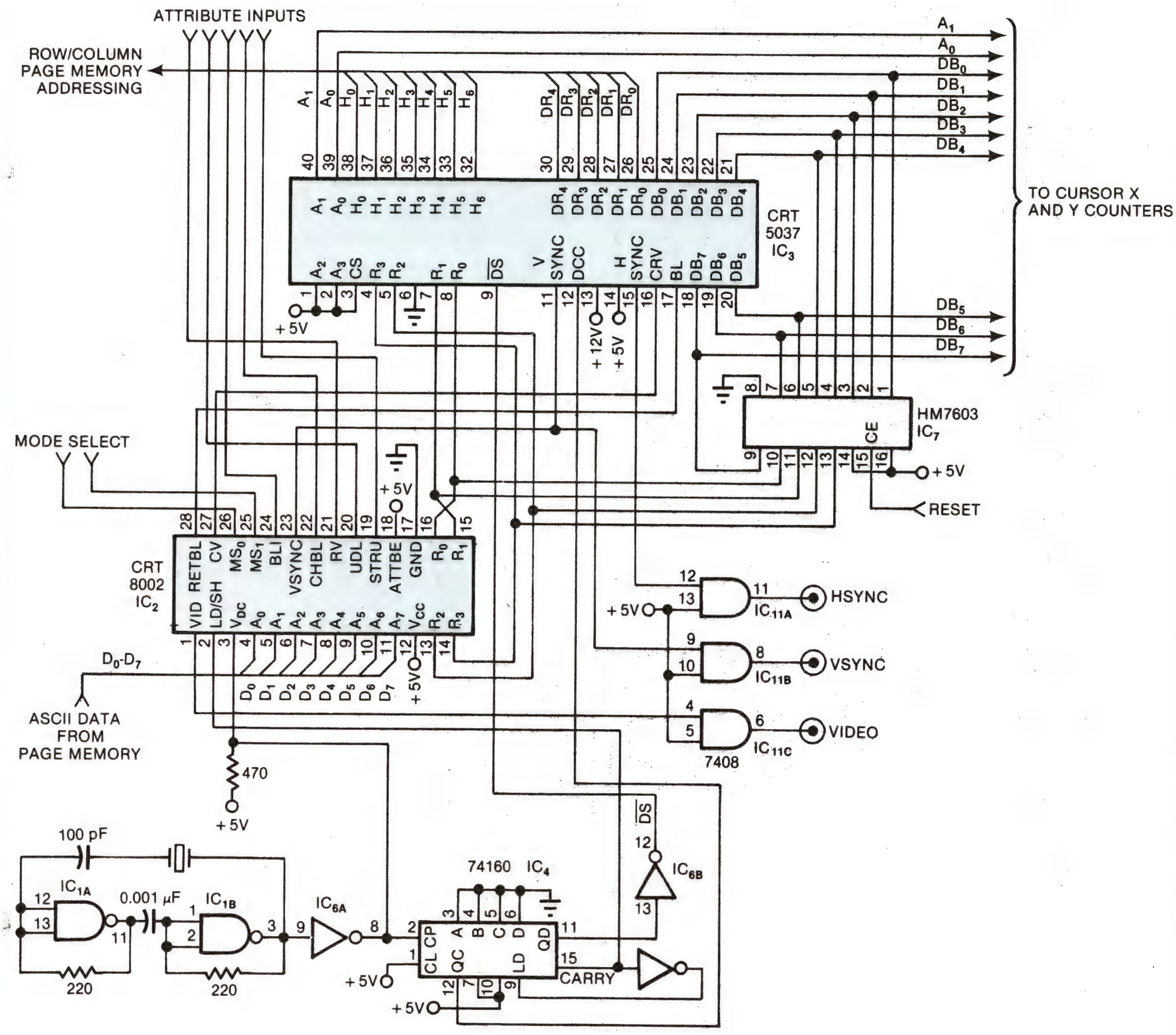


Fig 6—This basic CRT control circuit *suits both interlaced and noninterlaced formats—only the speed at which the circuit must operate (and thus the component types required) differs.*

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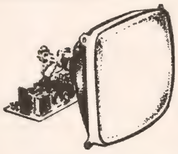

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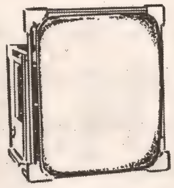

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MD3000—high performance 12-inch display module

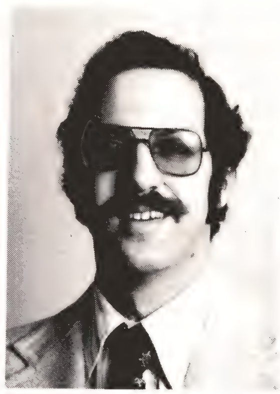
Interlaced and traditional formats utilize similar circuitry

the horizontal scan frequency multiplied by the number of character times per line. The latter quantity is itself typically 20 to 25% greater than the number of characters (to allow for retrace and margins), so F_{CC} equals (20,760)(80×1.25)=2.076 MHz. Finally, the video rate (the frequency at which characters are painted on the screen) equals F_{CC} times the number of dots per character=(2.076 MHz)(9)=18.684 MHz. Thus, the circuit shown in **Fig 6** would require a CRT 8002A 20-MHz character generator.

Note, however, that the 346 scan lines specified for this application fit easily into the 525 lines available from an interlaced scan design using a standard 15,750-Hz horizontal oscillator. For this approach, F_{CC} equals (15,750 Hz)(80×1.25)=1.575 MHz; the video rate is then 14.175 MHz. This alternative reduces the character-generator cost, because you can now utilize the less expensive 15-MHz CRT 8002B.

For a denser display—40 rows, for example—the comparison between interlaced and noninterlaced displays is even more dramatic. In noninterlaced mode, the horizontal scan frequency equals ((40×13)+21)(60)=32,460 Hz. To produce this frequency, you need customized monitor components as well as bipolar video components and character-generator ROM—at greatly increased cost—to handle the 29.214-MHz video rate required (for a 9×13 character block). Alternatively, an interlaced-scan system can produce this 40-row format utilizing the same components employed in the 25-row example. **EDN**

Author's biography



Brian Cayton, applications manager at Standard Microsystems Corp, Hauppauge, NY, provides customer technical support and presents seminars on MOS LSI. Holder of an MS degree in management as well as a BSEE, he has worked as an application engineer, regional sales manager and marketing manager. In his spare time, Brian plays tennis avidly.

Acknowledgement

The author wishes to thank Jay Popper and Len Novara for their help in preparing this article.

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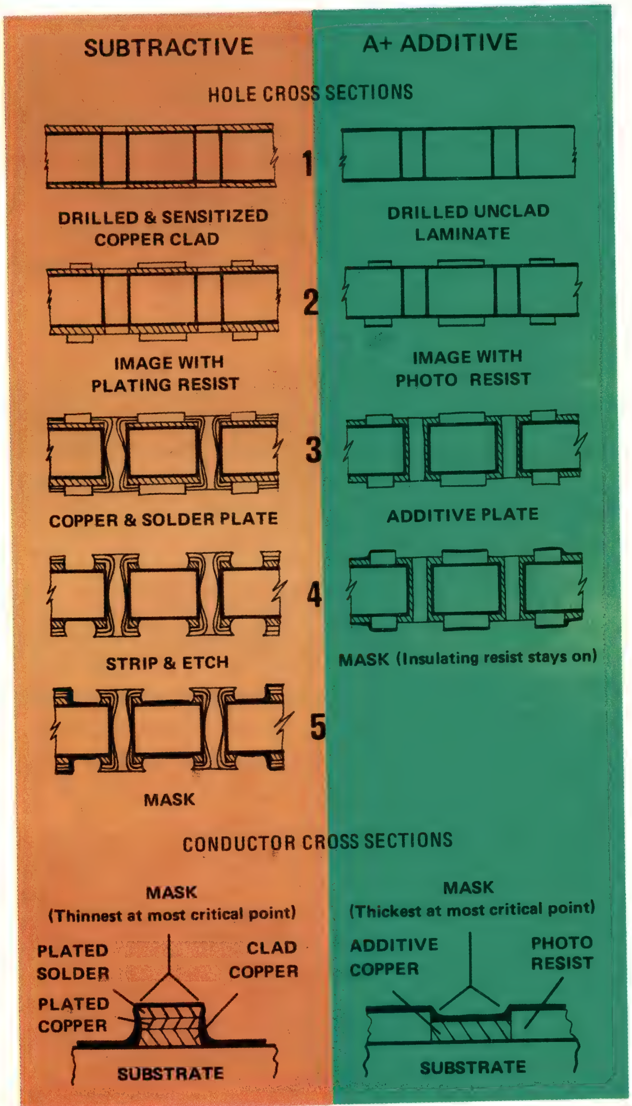

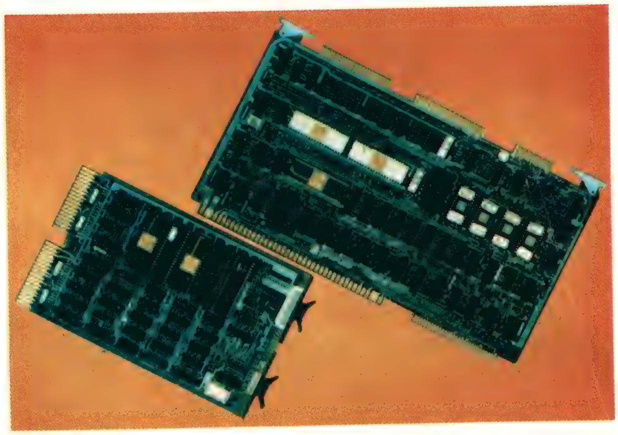

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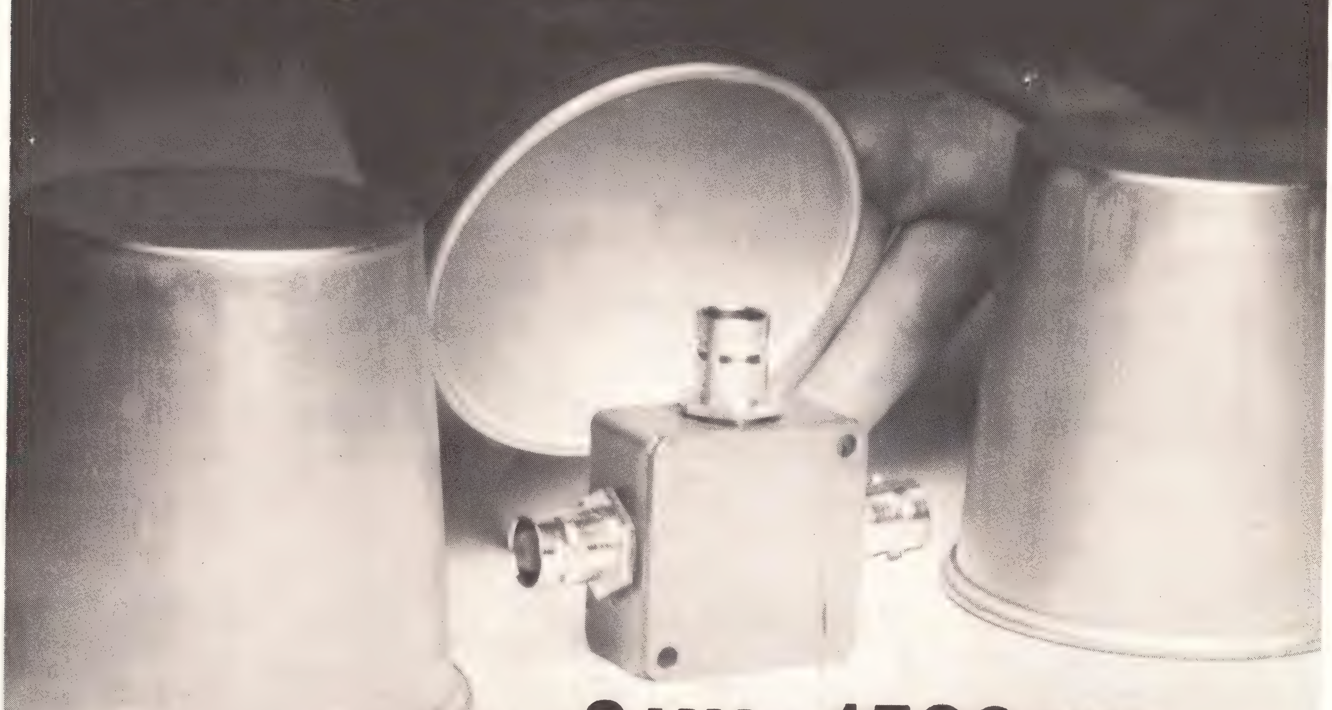

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Design Ideas

Active probe uses one op amp

Yishay Netzer
Haifa, Israel

Active probes prove an important oscilloscope accessory, allowing you to acquire signals from high-impedance sources with minimum loading. Their major disadvantage is their cost.

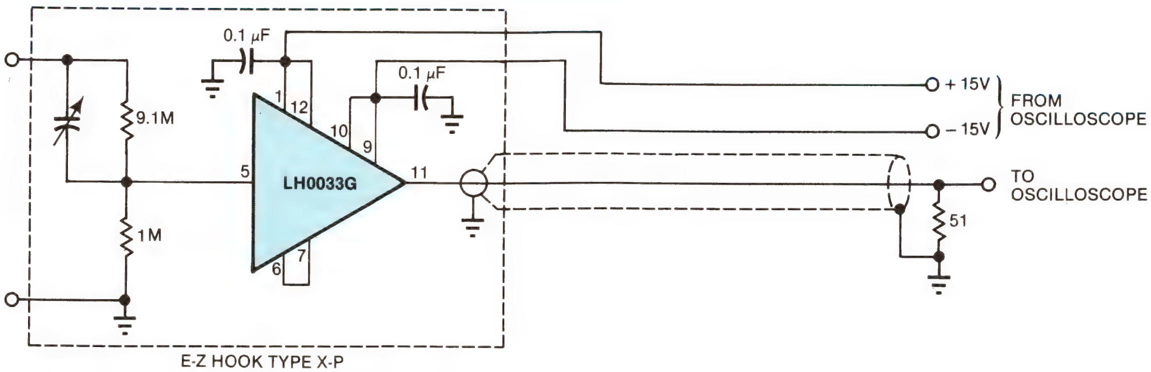
As an alternative to the high cost of such commercial probes, you can construct a simple device (**figure**) that uses an LH0033G ultrafast voltage follower to obtain a 50-MHz bandwidth.

The probe's basic configuration presents an input capacitance of 8 pF shunted by an arbitrary input-bias resistor (here 9.1 mΩ), but you can enhance performance by adding a compensated ×10 voltage attenuator, which lowers the input capacitance to approximately 1 pF and extends the unit's input-voltage range.

The probe's active portion drives a 50Ω coax, terminated at the oscilloscope; the scope itself furnishes the ±15V required for the probe's operation.

Enclosing the probe in an E-Z Hook Type X-P housing proves a simple task, because the housing provides a place for the printed circuit. **EDN**

To Vote For This Design, Circle No 450



Obtaining signals *from a high-impedance source with minimum loading proves a simple task for this active probe.*

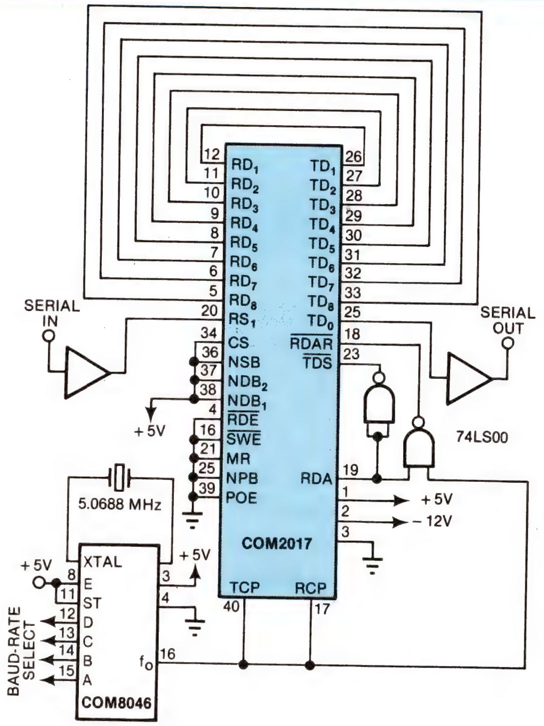
Asynchronous serial buffer uses UART

Brian Cayton
Standard Microsystems, Hauppauge, NY

When using amplifiers as repeaters in a serial data link, signal-distortion noise and jitter are amplified along with the desired signal. The circuit shown in the **figure** uses the receiver start-bit detection and receiver center-sampling features of a low-cost UART to reconstruct the incoming asynchronous data stream.

The UART uses a clock 16 times the actual baud rate to sample incoming data in the middle of a data bit. The internally generated sample strobe takes about 1 μsec, ensuring a distortion margin as well as noise immunity.

You invert the receiver data-available flag (RDA) to provide the transmitter data strobe (TDS); this signal loads the parallel data from the receiver into the transmitter and initiates transmission. The receiver clock gates RDA to provide the receiver data-available reset, preparing the UART for the next word. The clock pulse's negative edge enables the RDA, guaranteeing an adequate TDS pulse width from dc to 40k baud.



Using receiver start-bit detection *and center sampling, this circuit can reconstruct an incoming data stream.*

A B C D	BAUD RATE
0 0 0 0	50
1 0 0 0	75
0 1 0 0	110
1 1 0 0	134.5
0 0 1 0	150
1 0 1 0	300
0 1 1 0	600
1 1 1 0	1200
0 0 0 1	1800
1 0 0 1	2000
0 1 0 1	2400
1 1 0 1	3600
0 0 1 1	4800
1 0 1 1	7200
0 1 1 1	9600
1 1 1 1	19,200

The programming *of inputs A through D furnishes data.rates of 50 to 19.2k baud.*

For maximum accuracy, a baud-rate generator provides the crystal-controlled 16× clock. Program inputs A through D according to the **table** to obtain eight data bits, two stop bits and odd parity at the various data rates. **EDN**

To Vote For This Design, Circle No 451

Control μC-oscillator accuracy

James J Farrell
Motorola Semiconductor, Austin, TX

Many μP applications backed up by batteries call for a real-time clock, or at least a highly accurate one. This timekeeping function has become even more critical today because of the frequency of brownouts and blackouts—the 60-Hz line current generated by the power company is very accurate, but not very reliable.

A μP system using a real-time clock on a part- or full-time basis must operate within the specified accuracy of its system requirements, an accuracy that lies somewhere between that of a cesium atomic clock and a sand hourglass. But assume an accuracy requirement of 99.997685%—a number that's not entirely arbitrary, because it represents an error of 1 min/month, which many manufacturers use as a quasi standard. Stated another way, this figure represents an error no greater than ±23.15 ppm.

A μP with an on-board oscillator, such as the Motorola MC6808, can solve the real-time-clock design problem with minimum parts count and high reliability. (The on-board oscillators on the higher performance MC6801, MC6803 and MC6809 are virtually identical in frequency performance to that

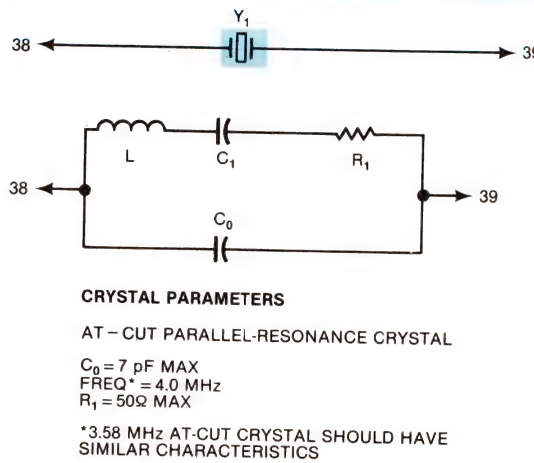


Fig 1—Crystal specification *proves crucial in determining the range of a system clock's accuracy adjustment.*

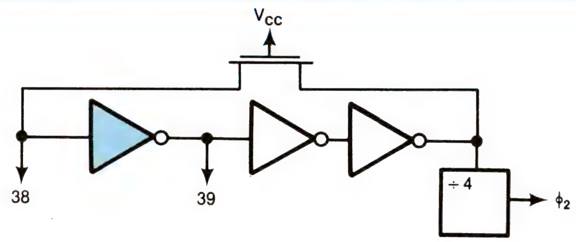


Fig 2—Internal oscillator operation *in the MC6808 µP relies on a special inverter between pins 38 and 39.*

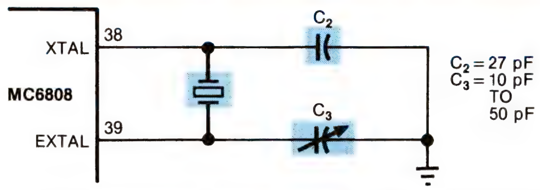


Fig 3—The temperature coefficients *of the fixed and variable capacitors also contribute to frequency error.*

on the MC6808.) The oscillator operates at a frequency four times greater than the internal ϕ_2 clock it develops—a provision that permits the use of a smaller, less expensive crystal. The MC6808 divides the oscillator frequency by four, buffers it and sends it to the outside world on the E (Enable) output.

Several factors determine overall system-clock accuracy; most are general oscillator-design considerations, and a few are unique to the MC6808's oscillator:

- The crystal's tolerance constitutes a major factor in determining the *range* of the accuracy adjustment; in itself, it does *not* determine the accuracy or stability of the oscillation frequency. It's important that the crystal be specified properly; **Fig 1** details the specification of a 4.0- or 3.58-MHz crystal. The recommended crystal tolerance (error) is ±50 ppm (indicating a reasonably inexpensive crystal).
- The oscillator, not the crystal, is the major source of frequency inaccuracy—a factor true for virtually all high-accuracy crystal-oscillator circuits. **Fig 2** describes the internal operation of the MC6808 oscillator. The inverter between pins 38 and 39 is not the usual one; instead, it has special characteristics enabling it to operate properly with the specified crystal. The crystal operates in parallel resonance.
- The only other significant cause of frequency error lies in the temperature coefficients of the fixed and variable capacitors **(Fig 3).** A ±5%, 27-pF mica capacitor is suggested for C_2; a glass-piston adjustable unit (screw type), for C_3.

Consider these frequency-error factors as noninteractive (mutually exclusive). To achieve a total real-time error of 1 min or less per month, you'll have to constrain the ambient temperature and/or power-supply (battery) voltage, but usually within a reasonable operating range. **EDN**

To Vote For This Design, Circle No 452

Gated oscillator maintains frequency

Wayne H Sanford Jr
Naval Air Development Center, Warminster, PA

Standard gated oscillators, such as the one shown in **Fig 1,** typically exhibit a first cycle 10 to 20% longer than subsequent cycles. This period difference results from a difference in the average charge on capacitor C when the oscillator is off, compared to when it is on.

You can correct this problem by using the circuit shown in **Fig 2.** When this circuit is off, the R_3, R_4 side of C is held to the average oscillator-output potential by the voltage divider; when the circuit is running, the 4016 switch connects that point to the oscillator's output. This configuration maintains a

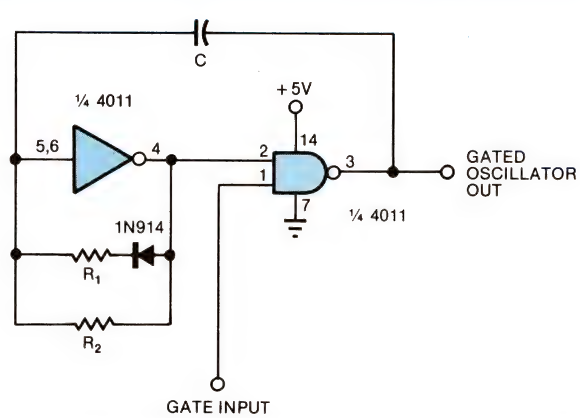


Fig 1—The first cycle *of a gated CMOS oscillator is typically 10 to 20% longer than its subsequent cycles.*

constant charge on C—the first cycle's period thus equals that of all other cycles.

The R_2C time constant determines the oscillator's up time (Fig 3), while the R_1C time constant determines the shorter down time. Keep R_1 greater than 10k. **EDN**

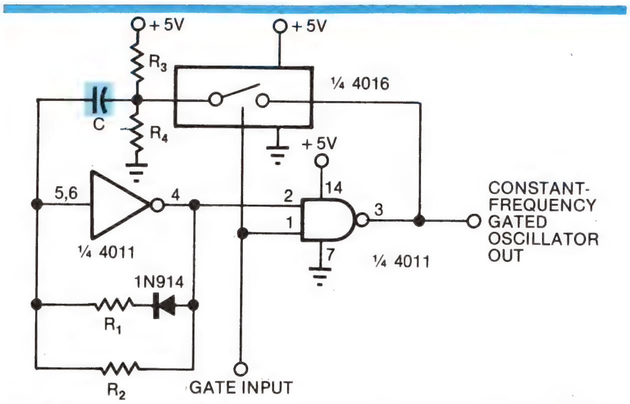


Fig 2—Maintaining a constant charge on C *stabilizes the output cycles.*

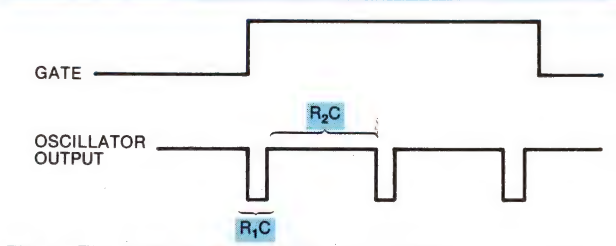


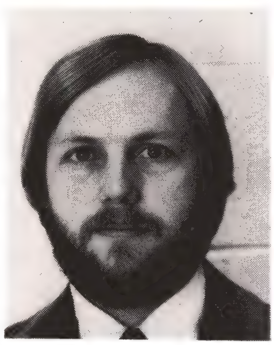
Fig 3—The time constant *of R_2 and C determines each cycle's up time; the down time is a function of R_1 and C.*

To Vote For This Design, Circle No 453

Readers have voted:

Gary Griesmyer winner of the May 20, 1978 US Savings Bond Award. His winning design is "Clocked CMOS one-shot has no RC time constant." Mr Griesmyer is with Naval Surface Weapons Center, Dahlgren, VA.

Sigurd L Lillevik winner of the September 20, 1978 US Savings Bond Award. His winning design is "Battery backup keeps CMOS RAMs alive." Mr Lillevik is with Utah State University, Logan, UT.



George J Stahl winner of the October 5, 1978 US Savings Bond Award. His winning design is "TTL clock provides wide frequency range." Mr Stahl is with the David W Taylor Naval Ship Research and Development Center, Annapolis, MD.

Sol L Black winner of the June 5, 1978 US Savings Bond Award. His winning design is "Use a 3-terminal regulator as an emitter follower." Mr Black is with Western Electric, Columbus, OH.

Nello Sevastopoulos and **Jim Moyer** winners of the September 5, 1978 US Savings Bond Award. Their winning design is "Micropower reference stays stable." Mr Sevastopoulos and Mr Moyer are with National Semiconductor Corp, Santa Clara, CA.

Henno Normet winner of the August 5, 1978 US Savings Bond Award. His winning design is "Detector protects 3-phase-powered equipment." Mr Normet is with Diversified Electronics, Evansville, IN.

Dan Dantuono winner of the April 20, 1978 US Savings Bond Award. His winning design is "Ramp generator features variable start/stop points." Mr Dantuono is with Fairchild Republic Co, Farmingdale, NY.

Paul M Brown winner of the April 5, 1978 US Savings Bond Award. His winning design is "Current limiters work with 3-terminal regulators." Mr Brown is with National Semiconductor Corp, Santa Clara, CA.

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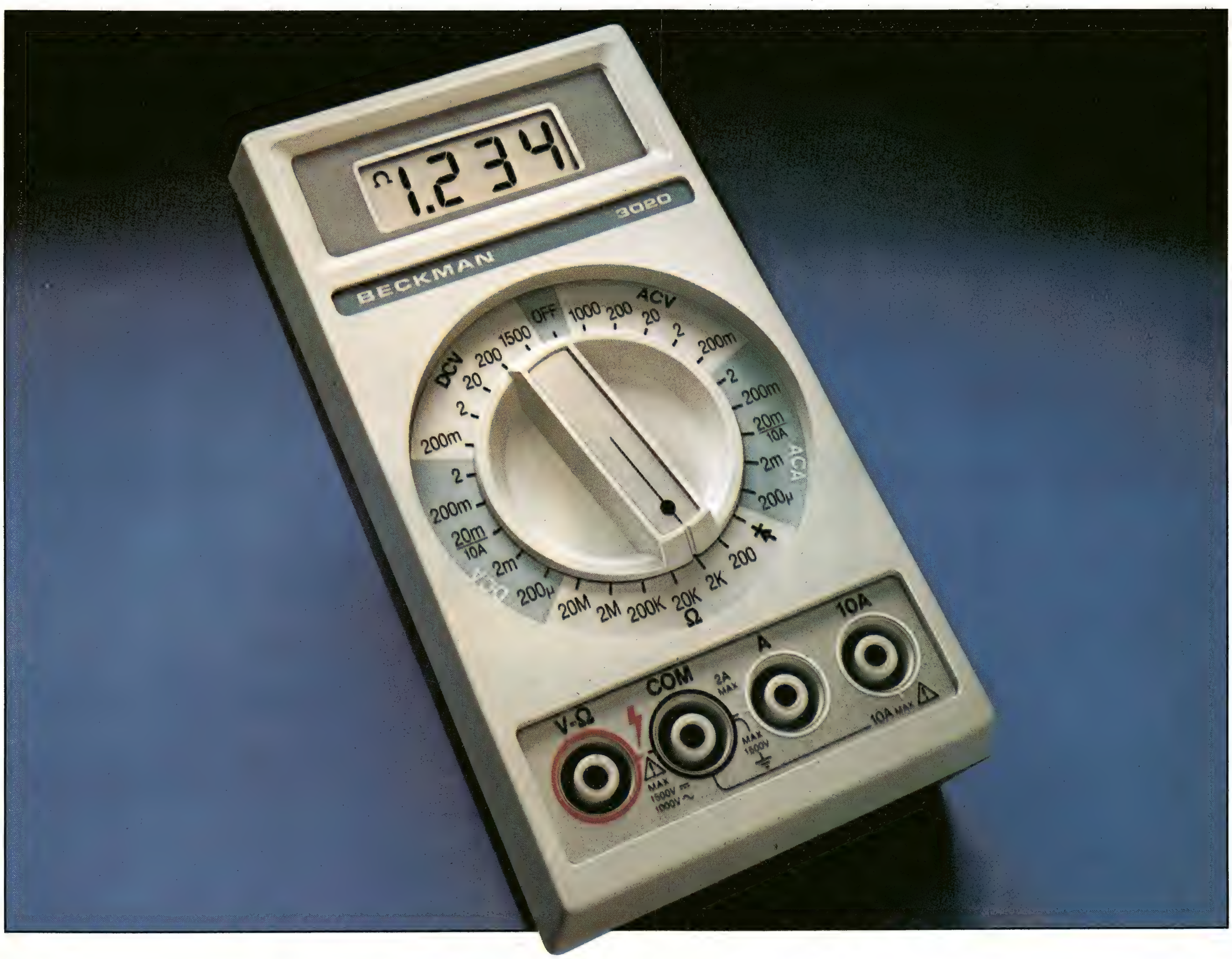

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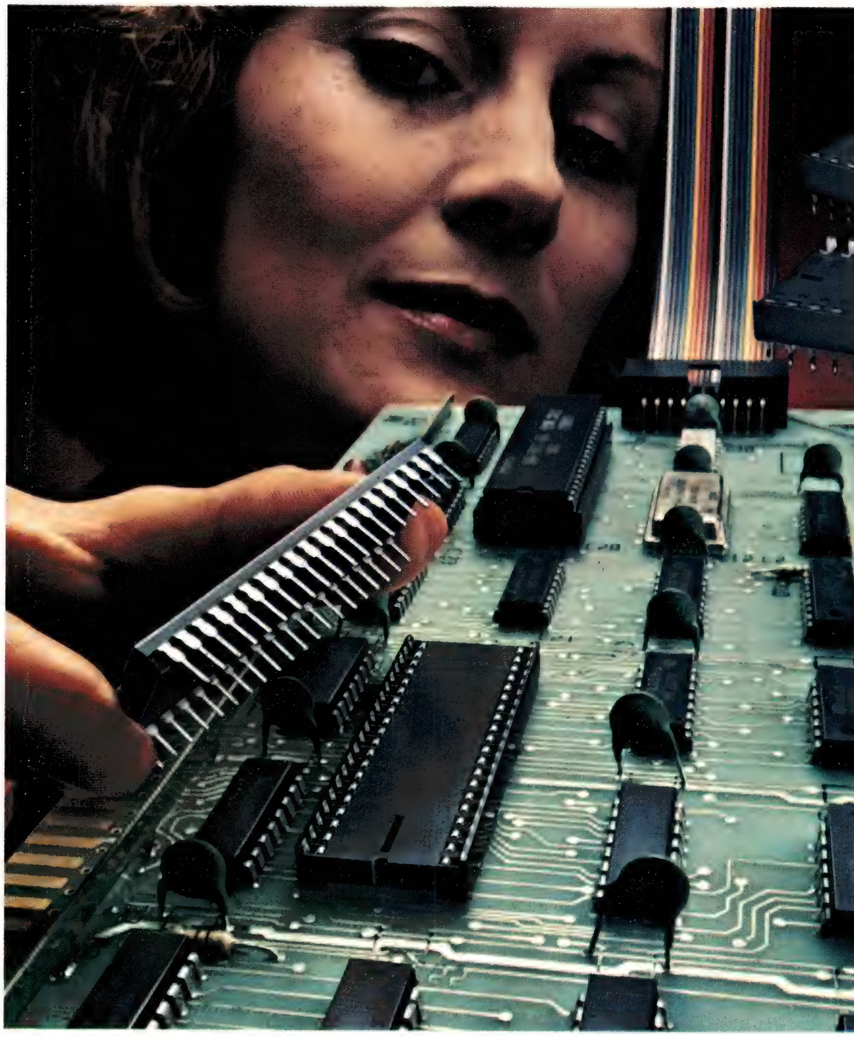

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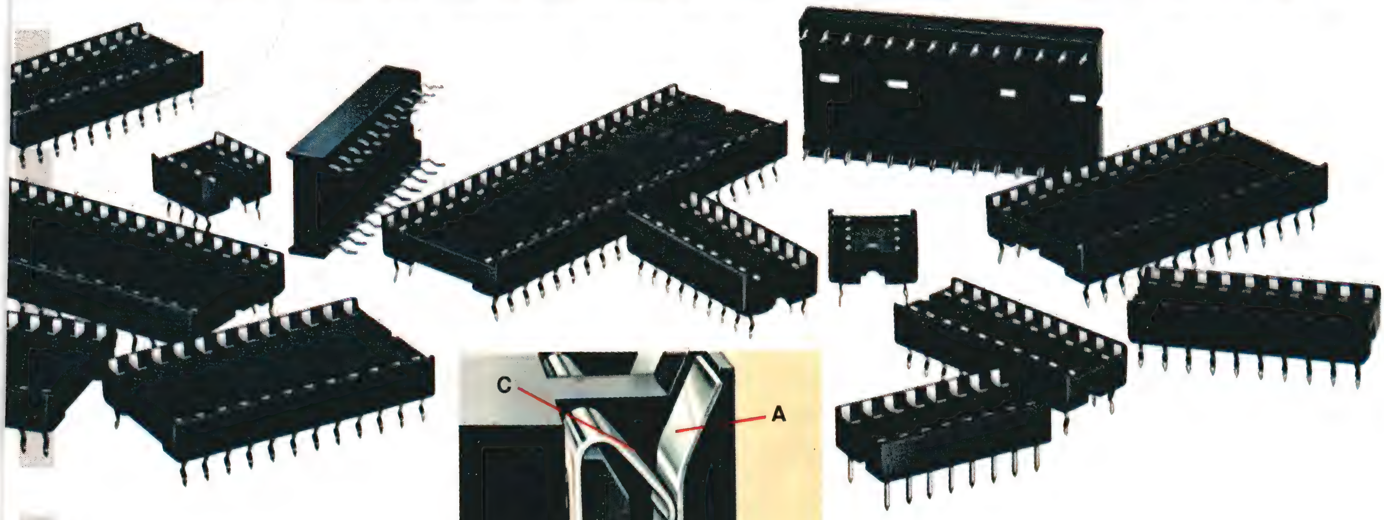
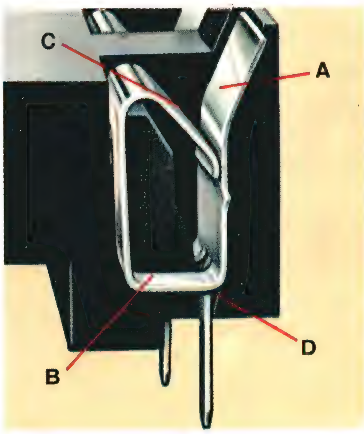
DIPLOMATE Sockets.





Some facts worth knowing about AMP DIPLOMATE Low Profile DIP Sockets.

Principal features:

A. Dual Wiping Contacts, with their redundant design, are much more reliable than single wiping contacts. In addition, the IC lead wipes only against the contact. It does not scrape plastic particles from the wall of the housing into the contact area where they can cause intermittancy problems.

B. Anti-overstress Stop Wall inside each contact cavity prevents damage to the contact beams by bent or twisted IC leads or from oversize pins or probes.

C. Large Target Entry Area of .050" x .050" makes hand loading of ICs both quick and easy. Virtually any automatic machine can handle it without stubbing because of the less critical X-Y tolerancing needed.

D. Closed Bottom Design prevents flux and solder contamination of the contact area caused by the wicking action found in open designs during flow soldering. The closed bottom holds solder tails rigid and straight to eliminate stubbing in the holes of a pc board during insertion.

Where to telephone: For quick delivery on most of these sockets, call AMP DIPLOMATE Socket Information Desk (717) 564-0100, Ext. 8400.

Where to write: AMP Incorporated, Harrisburg, PA 17105.

AMP

For more information, Circle No 107

Cartridge disc and software up development-system performance

Intended to offset the growing costs of software development, the Intellec Series II Model 240 provides 7.3M bytes of hard disc to handle larger files and achieve faster response times than floppy-based predecessors.

The system's software supports the latest release of 8086-family software (PL/M compiler and ASM-86 assembler) and the CREDIT screen-oriented editor. The latter allows you to type code, view it on the screen, correct errors and move the code to disc. Optional software permits scanning the disc's files for previously entered lines.

Series 3000 bipolar technology implements the system's disc controller. This 2-board interface supports two drives: The channel board receives, decodes and responds to channel commands, while the interface board validates data (during read cycle) with a cyclic-redundancy check.

Providing increased performance and program capacity *compared with its predecessors, the Intellec Series II Model 240 development system comes with a cartridge disc that decreases system response time.*

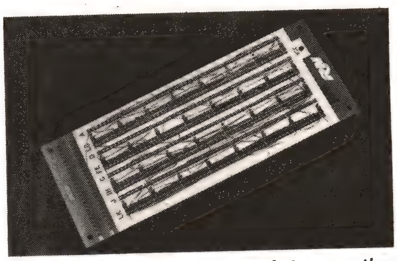
The balance of the development system's hardware includes its own CPU, 64k of RAM, a CRT with detachable keyboard, and interface circuitry that allows you to add a paper-tape punch/reader, printer or PROM programmer. A slave μP (8080A) handles all I/O functions and has its own 8k of ROM firmware and 8k of RAM for screen refresh. $21,990, including installation and on-site checkout.

***Intel Corp, 3065 Bowers Ave, Santa Clara, CA 95051. Phone (408) 987-8080.* Circle No 459**

Space-saving, low-cost prototype boards use insulation-displacement contacts

This point-to-point wiring system uses insulation-displacement techniques rather than wire-wrapping posts to greatly increase the packaging density of prototype pc boards. In fact, Quick/Connect WQC Series boards, sockets and terminals achieve a 40% space savings compared with 2-level wire-wrapping hardware; they permit a board profile of only 0.250 in. Thus, prototype boards can be accommodated in the same enclosure racks as finished units.

Making wiring connections is a simple process: Just push a 30-gauge solid-conductor hook-up wire into a slot in a terminal or socket. The insertion doesn't break the conductor and allows you to proceed to the next point in a daisy-chain wiring scheme with the minimum number of connections. Moreover, no wire stripping is needed; cutting is required only at end points, and

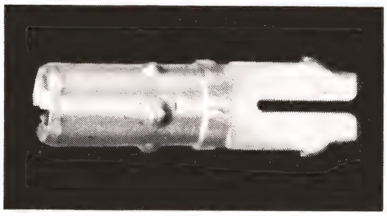


Wiring is point to point *on the Quick/Connect socket board; each connection has input and output potential. Because the slot on each socket or terminal accepts two wires, this low-profile (0.250-in.) assembly is equivalent to a 4-level wire-wrapping board.*

the resulting connections are easy to repair or modify. Each terminal or socket accepts two wires, equivalent to four wire-wrapping connections.

The board's gold-plated beryllium-copper I/O terminals come without internal contact springs and are designed for a compliant fit with 0.035-in.-diameter plated-through holes. They require no special soldering step to maintain electrical contact to the pc board.

A proven 4-fingered contact design is used in the system's sockets; contacts fit a 0.065-in.-diameter hole. Corner chamfers on the slot profile provide built-in strain relief, while a wire stop prevents component leads from disturbing the interconnect wiring and positions the wires properly in the



Slot shape *in Quick/Connect sockets and terminals is specially designed to act as a strain relief to prevent hookup wire from breaking during the interconnection process.*

tine. Heat treating minimizes wear and deformation of the slot.

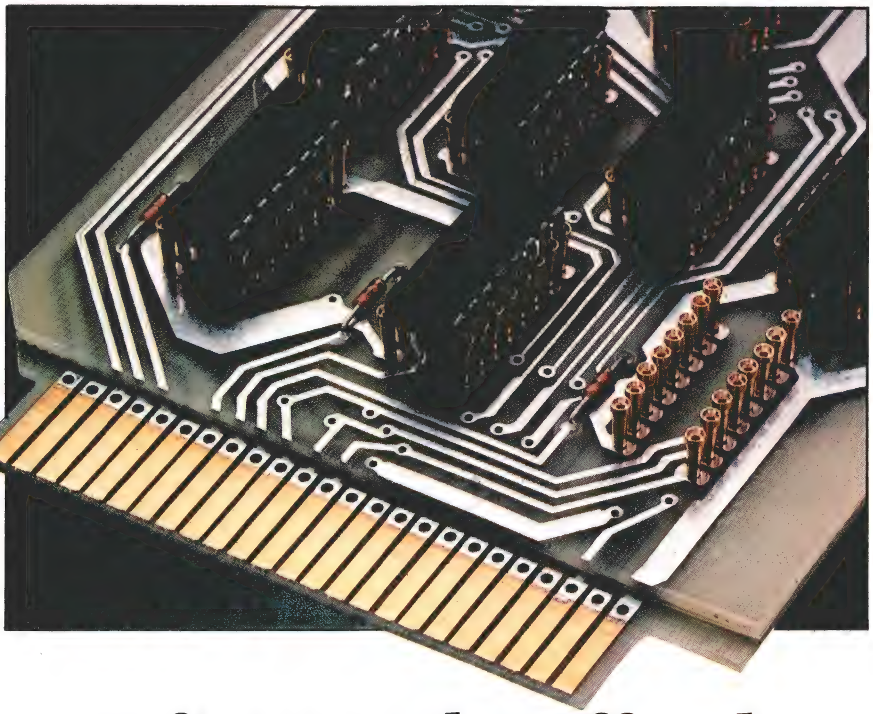
Sockets and terminals are available on strips for mass insertion, with tooling available for customer installation. However, the manufacturer can also preinstall the components in a customer-supplied pc board or provide universal-style packaging panels. The latter accept DIPs on 0.300-, 0.400- and 0.600-in. centers and come in sizes containing one to six groups (each group measures 2.675 in. wide.) The companion CH-1 Series packaging system holds two 6-group boards.

Model WQC-UNI-1 socket board ($65.40) contains one group and measures 6.875× 2.675 in. QC-5068-175G socket, $0.09 (1000); QC-175-G terminal, $0.06 (1000). Support includes the Model QCT-1 hand wiring tool ($8.45) and the Model QCT-10 die set ($130), which presses up to 10 sockets or terminals into a board at one time. Volume customer board-assembly equipment is currently being developed.

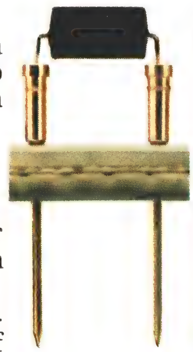
Robinson-Nugent Inc, 800 E Eighth St, New Albany, IN 47150. Phone (812) 945-0211.

Circle No 460

Expanding the parameters of press-fit technology



New press-fit I.C. socket offers lower cost, higher density and cooler operation.



Low Cost
Using a conventional precision screw machine contact, press-fit into the circuit board, this new socket is a major improvement over time-proven packaging methods. This innovative conversion to press-fit techniques greatly increases cost effectiveness by reducing need for external wiring and the elimination of soldering.

Characteristics of the new socket allow us to selectively plate a portion of the tails with significant savings in gold plating.

High Density—Greater Design Freedom
The new socket stands rather high on the board (.190")—but with good reason.

The .062 pad now allows a trace to be run between contact holes for greater circuit density. This should allow a drop from a 3-wrap tail to a 2-wrap—or no tail at all. The 2-wrap offers about the same spacing as a conventional low profile socket with 3-wrap tail. Used in an Elfab Multi-Pac® system, you can get up to six planes of circuitry on a modular daughter board or backpanel. You eliminate the need for complex and expensive multilayered boards.

Cooler Operation
Since the socket stands up off the board, air flow aids in heat dissipation giving you much cooler operating temperatures. This is especially significant with higher pin count IC's.

Oriented Contact — both clip and contact tail.
Clip is so oriented that the four contact tines are in perfect alignment with the IC lead. Each tail is oriented square and parallel with the others to accept a mating connector when desired.

An Elfab exclusive!

For additional information contact:

ELFAB
The Leader in Press-fit Technology
P. O. Box 34555 • Dallas, Texas 75234 • 214-233-3033

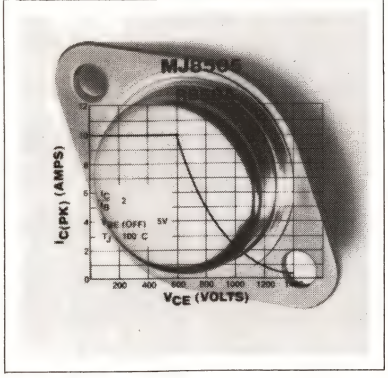
For more information, Circle No 113


When you're searching
for component solutions . . .
Centralab ceramic capacitors
give you
unparalleled selection
and service...

New Products

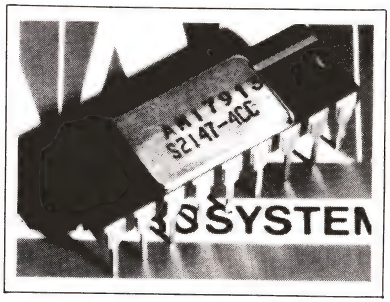
ICs & SEMICONDUCTORS

12-BIT DAC. Pin compatible with 562-type converters, the DAC862 2-quadrant multiplying DAC offers ¼-LSB nonlinearity, ±5-ppm/°C maximum gain drift and ±4-ppm/°C bipolar offset drift. Monotonic over its operating-temperature range, the 24-pin DIP has a 3.5-μsec settling time. Used as a multiplier, it has a minimum accuracy of ±0.05%. The 2-chip hybrid device requires −15V and either +5 or +15V supplies, along with an external reference voltage. $24 (100). **Burr-Brown**, Box 11400, Tucson, AZ 85734. Phone (602) 746-1111. **Circle No 240**



FAST TRANSISTORS. MJ8500 Series npn fast-switching power transistors can operate directly off a 220V line. Designed for high-voltage, high-speed power switching in inductive circuits, they offer a range of $V_{CEO(sus)}$ ratings up to 800V and maximum I_C ratings as high as 10A. The specified reverse-biased-switching safe-operating areas extend switching ratings to 1400V. All devices come in TO-3-shaped packages. From $2.15 (100) ($I_C$=2.5A, V_{CEO}=700V, t_f=2 μsec at 1A). **Motorola Semiconductor Products Inc**, Box 20912, Phoenix, AZ 85036. Phone (602) 244-6900. **Circle No 241**

New Products

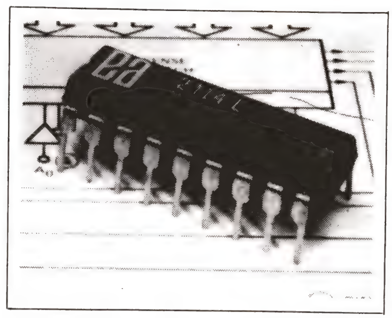


4k VMOS RAM. Featuring the industry-standard 55-nsec access time, the S2147-3 VMOS RAM is organized as 4k×1 bits; a slower version (S2147-5) has a 70-nsec access time. Both models are fully TTL compatible and use a +5V supply. Fully static, they need no clocks or refresh cycles. The 18-pin chips include an automatic power-down capability. $26 (1000). Delivery, 75 days ARO. **American Microsystems Inc,** 3800 Homestead Rd, Santa Clara, CA 95051. Phone (408) 246-0330.

Circle No 242

CRT SHIFT REGISTER. Claimed to be the only 8-byte-wide shift register, the MM5034 finds use with a DP8350 CRT controller. Together, they simplify applications in CRT-terminal designs which make heavy use of memory to update screen information. The 22-pin device has TTL-compatible inputs and outputs, runs on +5V and contains Tri-state output buffers. A 20-lead version, the MM5035, omits the Tri-state feature. MM5035, $8.16; MM5034, $8.40 (100). **National Semiconductor,** 2900 Semiconductor Dr, Santa Clara, CA 95051. Phone (408) 737-5000.

Circle No 243



4k RAM. The EA2114L 1k×4-bit static RAM offers five access-time options ranging from 150 to 450 nsec. TTL compatible and operable on a +5V supply, this 18-pin unit features wide design margins including ±10% supply tolerance and 80°C/W package thermal resistance. 450-nsec EA2114L, $7.65

SORENSEN

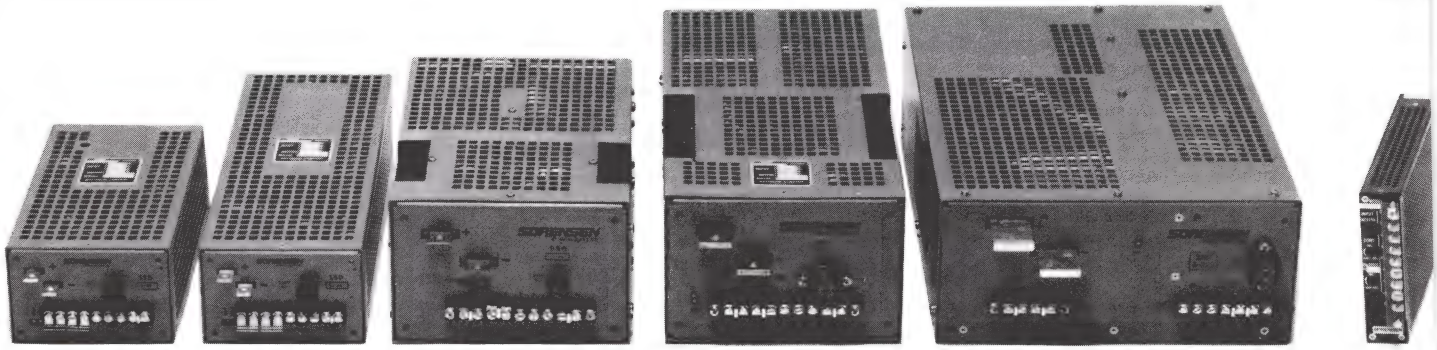
Modular Switching Power Supplies

Sorensen is the source for three different types of modular switching power supplies. 96 different models. 8 package sizes. 5 year warranty.

Three different types of switching power supply

SSD Series

SL



III IIIA IVB VIA X 1

Now Sorensen offers you three different types of modular switching power supply. Will one meet your requirements?

The Sorensen SSD series, STM series and SLC series offer 202 different input/output voltage configurations from 96 different models in only 9 different packages. A broad selection; but simple to specify.

Simple to specify, because Sorensen has over 35 years experience in building power supplies. Series pass (linear), phase control, pre-regulated; as well as high frequency switching. Experience in millions of different applications. Experience we put into every product.

Reliability: Every Sorensen switching power supply is conservatively designed. Components run well below their specified ratings. All models below 1000 watts are convection cooled offering improved efficiency and reduced heat dissipation problems.

Versatility: Multiple input capability is standard on every Sorensen switcher. The SSD series offers 115/220 Vac input selectable from the terminal board. The STM series, with 40 models, offers all output voltages from 3V to 56Vdc. Output voltage adjustment ranges on the STM offer a designer the flexibility to match a wide variety of load characteristics.

Performance Vs. Cost: If you're looking for tight specifications and outstanding performance. The SSD series will meet your requirements. If you can live with a little less performance at a lot less dollars, take a look at the SLC series.

Five year Warranty: Every Sorensen switcher is covered by a comprehensive five year warranty. Warranty service is available from the main factory or any factory franchised service center throughout the world. Alternatively customers may re-calibrate, trouble-shoot or repair products as described in the instruction manual without voiding the warranty. Warranty replacement parts are available to customers at no charge.

The unused portion of the warranty is fully transferable from the original purchaser if the supply is a component in the original purchaser's product or system.

After five years, spare parts and service are available at a reasonable charge from all field service representatives and the main factory.

Modular Switching Power Supplies

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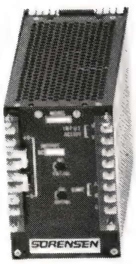
2



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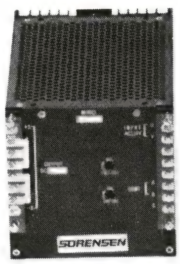

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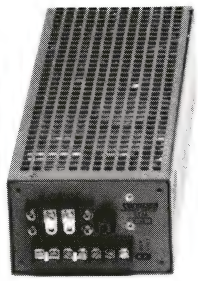
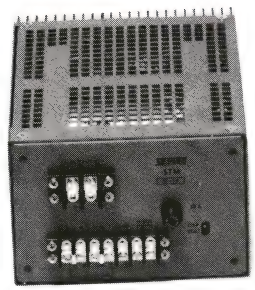
STM Series

III



IIIA



IVA

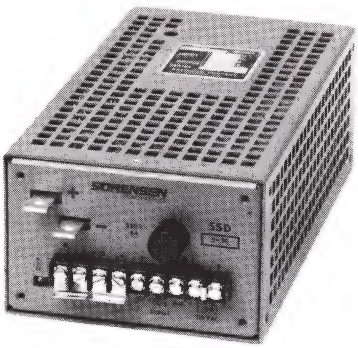
VI

General Specifications

	SSD	STM	SLC
Nominal output Voltage (Vdc)	5 to 48	3.5 to 48	5 to 24
Max. Output power (Watts)	1,125	780	150
Efficiency (depending on Model)	65 to 80%	60 to 80%	63 to 81%
Input Voltage Vac	110/220	110	110
Vdc	255-345	127-173	120-165
Hold-up Time (full load minimum)	40ms	15ms	30ms
Parallel Operation	X	X	X
Overvoltage Protection	X	X	X
Overload Protection/Current Limiting	X	X	X
Remote Sensing	X	X	X
Remote Programming	X	X	
Soft Start	X	X	
Logic Shutdown	X		

Detailed specifications are on the following pages.

SSD Series



Features

- ☐ 36 Models, 5V to 48Vdc with power levels up to 1,125 watts
- ☐ 115/220Vac or 255-345Vdc input
- ☐ Wide range output voltage adjustment
- ☐ Built-in adjustable overvoltage protection on all models
- ☐ Adjustable current limiting (20% to 150% full load current)
- ☐ Low ripple and noise through the use of double stage filtering
- ☐ Hold-up time minimum 80ms half load, 40ms full load
- ☐ U.L. listed
- ☐ 5 year warranty

Specifications

Input

Voltage: 98-132Vac single phase
187-250V ac single phase
255-345V dc

SSD 5-225 (1,000 Watt unit):
105-125Vac single phase
210-250Vac single phase
275-325Vdc

Frequency: 47-440 Hz operation without derating
360-440 Hz (Double rms ripple spec)

Output

Regulation:
Line: 0.01% +1mV
Load: 0.01% +1mV

STM Series

Features

- ☐ 40 Models. 3.5V to 48Vdc with power levels up to 780 watts
- ☐ 105-132Vac or 127-173Vdc input
- ☐ Wide range output voltage adjustment
- ☐ Built-in adjustable overvoltage protection on all models
- ☐ Adjustable current limiting (50% to 150% full load current)
- ☐ Low ripple and noise
- ☐ 5 year warranty

Specifications

Input

Voltage:
105–132V ac single phase or
127–173V dc

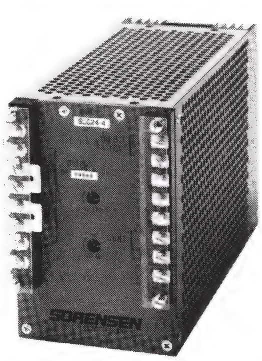
Frequency:
50–440 Hz operation without derating.

Output

Regulation:
Line: 0.025% + 1mV.
Load: 0.025% + 1mV.

Ripple:
Typical, 5mV rms, 30mV pk-pk.
Maximum, 10mV rms, 50mV pk-pk.

SLC Series



Features

- ☐ 20 Models, 5V to 24Vdc with power levels up to 150 watts
- ☐ 92-127Vdc or 120-165Vdc
- ☐ Wide range adjustable output
- ☐ High Efficiency (up to 81%)
- ☐ Built-in overvoltage protection adjustable to within 25% of voltage setting
- ☐ Overload protection/automatic current limiting starting at 115% full load
- ☐ Remote sensing and shutdown
- ☐ 5 year warranty

Specifications

Input

Voltage: 92-127V ac single phase or 120-165V dc

Frequency: 47-440 Hz operation without derating

Brown Out Protection: 115V ac, +10%, −20%

Output

Regulation:
Case 1

Modular Switching Power Supplies

Ripple:
Typical: 5mV rms, 20mV pk-pk
Maximum: 8mV rms, 50mV pk-pk
SSD 5-225 (1,000 watt unit)
Typical: 7mV rms, 80mV pk-pk
Maximum: 10mV rms, 100mV pk-pk

Temperature Coefficient: 0.01% maximum per °C

Stability: 0.05% maximum for 24 hours after warm-up of 30 minutes

Transient Response Time: Output voltage returns to within 1% in less than 1.5ms following a step load change of 25% to 75% or 75% to 25%.

Overshoot: Less than 1% on turn-on, turn-off or power failure.

Operating Data

Efficiency: 65 to 80% depending on model.

Remote Sensing: Terminals are provided on front panel. As long as terminal voltage remains within specified range, there are no basic limitations on load lead drop.

Remote Programming:
Resistance remote programming 1000/Volt
Voltage remote programming Volt/Volt

Remote shutdown: Output voltage can be shut down by placing 100 ohms or less in shutdown circuit. TTL compatible.

Series Operation: Up to 100Vdc maximum output.

Parallel Operation: May be directly paralleled without derating.

Soft-start: In-rush current is limited by soft-start circuit.

Isolation (Breakdown test):
2.1kV dc input to chassis
2.1kV dc input to output
500V dc output to chassis

Ambient Operating Temperature: 0 to 70°C

Storage Temperature: −55 to +85°C

Cooling: Convection cooled (except SSD 5-225—fan cooled).

Finish: Textured blue thermal paint.

Temperature coefficient:
0.01% maximum per °C

Stability:
0.05% for 24 hours after warm-up of 30 minutes.

Transient response time:
Output voltage returns to within ±1% in less than 1ms following a step-load change for either 50% to 100% or 100% to 50% of full load.

Overshoot:
No overshoot on turn-on, turn-off or power failure.

Hold-up time:
Full regulated voltage holds up for 15ms after removal of power at full load and nominal input and output voltages. (30ms for half load).

Operating data

Efficiency:
60 to 80% depending on model.

Remote sensing:
As long as terminal voltage does not exceed maximum output rating there are no basic limitations on load lead drop.

Remote programming:
Resistance remote programming; 1000Ω/V
Voltage remote programming; Volt/Volt

Series operation:
200V dc maximum output.

Parallel operation:
May be directly paralleled without derating.

Soft start:
In-rush current is limited by soft-start circuit.

Isolation (breakdown test):
1.3kV dc input to chassis.
300 V dc output to chassis.

Ambient operating temperature:
0 to +70°C.

Storage temperature:
−40 to +85°C.

Cooling:
Convection cooled.

Finish:
Textured blue thermal paint

Line: 0.3% maximum
Load: 0.2% maximum
Case 2, 3 and 4
Line: 0.1% maximum
Load: 0.1% maximum

Ripple: 5V models
Maximum, 50m V pk-pk
9V-24V models
Maximum, 100mV pk-pk

Temperature Coefficient: 0.02% maximum per °C

Stability: 0.1% maximum for 8 hours after 30-minute warm-up.

Transient Response Time: Output voltage returns to within ±0.5% in less than 1.5ms maximum at 150V ac following a step load change from 50% to 100% of full load.

Overshoot: No overshoot at turn-on, turn-off or power failure.

Hold-up Time: Full regulated voltage holds up for 30ms after removal of power at full load and nominal input and output voltages.

Operating Data

Series/Parallel Operation: Up to 4 units maximum.

Isolation: 1.5kV ac or 500V dc input to output terminals or case; resistance 30 megohms minimum.

Ambient Operating Temperature: −10 to +70°C

Storage Temperature: −25 to +85°C

Cooling: Convection Cooled

Finish: Textured blue thermal paint

Model Specifications

Output Voltage Adjustment (Vdc)	Min.	Max.	Current @ 40° C	Input Voltage Vac	Regulation Line	Regulation Load	Ripple mVrms (typ)	Ripple mVpk-pk (typ)	Case	Price
3.5 Volt										
STM 3.5-24	3.0	4.5	24	115Vac • 127-173Vdc	0.025% + 1mV	0.025% + 1mV	5	30	III	$ *
STM 3.5-36	3.0	4.5	36	115Vac • 127-173Vdc	0.025% + 1mV	0.025% + 1mV	5	30	IIIA	*
STM 3.5-60	3.0	4.5	60	115Vac • 127-173Vdc	0.025% + 1mV	0.025% + 1mV	5	30	IVA	*
STM 3.5-100	3.0	4.5	100	115Vac • 127-173Vdc	0.025% + 1mV	0.025% + 1mV	5	30	VI	*
5 Volt										
SLC 5-5	4.5	5.5	5	115Vac • 120-165Vdc	0.3%	0.2%	–	50 (max)	1	$155.00
SLC 5-10	4.5	5.5	10	115Vac • 120-165Vdc	0.1%	0.1%	–	50 (max)	2	205.00
SLC 5-20	4.5	5.5	20	115Vac • 120-165Vdc	0.1%	0.1%	–	50 (max)	3	250.00
STM 5-24	4.5	6.0	24	115Vac • 127-173Vdc	0.025% + 1mV	0.025% + 1mV	5	30	III	350.00
SSD 5-30	4.7	6.5	30	115/220Vac • 255-345Vdc	0.01% + 1mV	0.01% + 1mV	5	20	III	345.00
SLC 5-30	4.5	5.5	30	115Vac • 120-165Vdc	0.1%	0.1%	–	50 (max)	4	300.00
STM 5-36	4.5	6.0	36	115Vac • 127-173Vdc	0.025% + 1mV	0.025% + 1mV	5	30	IIIA	460.00
SSD 5-45	4.7	6.5	45	115/220Vac • 255-345Vdc	0.01% + 1mV	0.01% + 1mV	5	20	IIIA	470.00
STM 5-60	4.5	6.0	60	115Vac • 127-173Vdc	0.025% + 1mV	0.025% + 1mV	5	30	IVA	625.00
SSD 5-75	4.7	6.5	75	115/220Vac • 255-345Vdc	0.01% + 1mV	0.01% + 1mV	5	20	IVB	650.00
STM 5-100	4.5	6.0	100	115Vac • 127-173Vdc	0.025% + 1mV	0.025% + 1mV	5	30	VI	800.00
SSD 5-120	4.7	6.5	120	115/220Vac • 255-345Vdc	0.01% + 1mV	0.01% + 1mV	5	20	VIA	790.00
SSD 5-150	4.75	5.25	150	115/220Vac • 255-345Vdc	0.01% + 1mV	0.01% + 1mV	5	20	VIA	950.00
SSD 5-225	4.75	5.25	225	115/220Vac • 255-345Vdc	0.01% + 1mV	0.01% + 1mV	7	80	X	1450.00
9 Volt										
STM 9-12	6.0	10.0	12	115Vac • 127-173Vdc	0.025% + 1mV	0.025% + 1mV	5	30	III	$ *
SSD 9-20	6.5	9.5	20	115/220Vac • 255-345Vdc	0.01% + 1mV	0.01% + 1mV	5	20	III	345.00
STM 9-20	6.0	10.0	20	115Vac • 127-173Vdc	0.025% + 1mV	0.025% + 1mV	5	30	IIIA	*
SSD 9-30	6.5	9.5	30	115/220Vac • 255-345Vdc	0.01% + 1mV	0.01% + 1mV	5	20	IIIA	470.00
STM 9-30	6.0	10.0	30	115Vac • 127-173Vdc	0.025% + 1mV	0.025% + 1mV	5	30	IVA	*
SSD 9-50	6.5	9.5	50	115/220Vac • 255-345Vdc	0.01% + 1mV	0.01% + 1mV	5	20	IVB	650.00
STM 9-50	6.0	10.0	50	115Vac • 127-173Vdc	0.025% + 1mV	0.025% + 1mV	5	30	VI	*
SSD 9-80	6.5	9.5	80	115/220Vac • 255-345Vdc	0.01% + 1mV	0.01% + 1mV	5	20	VIA	790.00
12 Volt										
SLC 12-2	10.8	13.2	2	115Vac • 120-165Vdc	0.3%	0.2%	–	100 (max)	1	$155.00
SLC 12-4	10.8	13.2	4	115Vac • 120-165Vdc	0.1%	0.1%	–	100 (max)	2	205.00
SLC 12-8	10.8	13.2	8	115Vac • 120-165Vdc	0.1%	0.1%	–	100 (max)	3	250.00
STM 12-12	9.5	13.5	12	115Vac • 127-173Vdc	0.025% + 1mV	0.025% + 1mV	5	30	III	350.00
SLC 12-12	10.8	13.2	12	115Vac • 120-165Vdc	0.1%	0.1%	–	100 (max)	4	300.00
SSD 12-15	9.5	13.0	15	115/220Vac • 255-345Vdc	0.01% + 1mV	0.01% + 1mV	5	20	III	345.00
STM 12-20	9.5	13.5	20	115Vac • 127-173Vdc	0.025% + 1mV	0.025% + 1mV	5	30	IIIA	460.00
SSD 12-22	9.5	13.0	22	115/220Vac • 255-345Vdc	0.01% + 1mV	0.01% + 1mV	5	20	IIIA	470.00
STM 12-30	9.5	13.5	30	115Vac • 127-173Vdc	0.025% + 1mV	0.025% + 1mV	5	30	IVA	625.00
SSD 12-38	9.5	13.0	38	115/220Vac • 255-345Vdc	0.01% + 1mV	0.01% + 1mV	5	20	IVB	650.00
STM 12-50	9.5	13.5	50	115Vac • 127-173Vdc	0.025% + 1mV	0.025% + 1mV	5	30	VI	800.00
SSD 12-60	9.5	13.0	60	115/220Vac • 255-345Vdc	0.01% + 1mV	0.01% + 1mV	5	20	VIA	790.00
15 Volt										
SLC 15-1	13.5	16.5	1	115Vac • 120-165Vdc	0.3%	0.2%	–	100 (max)	1	$155.00
SLC 15-3	13.5	16.5	3	115Vac • 120-165Vdc	0.1%	0.1%	–	100 (max)	2	205.00
SLC 15-6	13.5	16.5	6	115Vac • 120-165Vdc	0.1%	0.1%	–	100 (max)	3	250.00
STM 15-10	13.0	17.0	10	115Vac • 127-173Vdc	0.025% + 1mV	0.025% + 1mV	5	30	III	350.00
SLC 15-10	13.5	16.5	10	115Vac • 120-165Vdc	0.1%	0.1%	–	100 (max)	4	300.00
SSD15-12	13.0	17.0	12	115/220Vac • 255-345Vdc	0.01% + 1mV	0.01% + 1mV	5	20	III	345.00
STM 15-15	13.0	17.0	15	115Vac • 127-173Vdc	0.025% + 1mV	0.025% + 1mV	5	30	IIIA	460.00
SSD 15-18	13.0	17.0	18	115/220Vac • 255-345Vdc	0.01% + 1mV	0.01% + 1mV	5	20	IIIA	470.00
STM 15-24	13.0	17.0	24	115Vac • 127-173Vdc	0.025% + 1mV	0.025% + 1mV	5	30	IVA	625.00
SSD 15-32	13.0	17.0	32	115/220Vac • 255-345Vdc	0.01% + 1mV	0.01% + 1mV	5	20	IVB	650.00
STM 15-32	13.0	17.0	32	115Vac • 127-173Vdc	0.025% + 1mV	0.025% + 1mV	5	30	VI	800.00
SSD 15-45	13.0	17.0	45	115/220Vac • 255-345Vdc	0.01% + 1mV	0.01% + 1mV	5	20	VIA	790.00

Modular Switching Power Supplies

Model Specifications

Output Voltage Adjustment (Vdc)	Min.	Max.	Current @ 40° C	Input Voltage Vac	Regulation Line	Regulation Load	Ripple mVrms (typ)	Ripple mVpk-pk (typ)	Case	Price
18 Volt										
STM 18-10	16.0	20.0	10	115Vac • 127-173Vdc	0.025% + 1mV	0.025% + 1mV	5	30	III	$ *
SSD 18-10.5	16.0	21.0	10.5	115/220Vac • 255-345Vdc	0.01% + 1mV	0.01% + 1mV	5	20	III	345.00
STM 18-15	16.0	20.0	15	115Vac • 127-173Vdc	0.025% + 1mV	0.025% + 1mV	5	30	IIIA	*
SSD 18-16	16.0	21.0	16	115/220Vac • 255-345Vdc	0.01% + 1mV	0.01% + 1mV	5	20	IIIA	470.00
STM 18-24	16.0	20.0	24	115Vac • 127-173Vdc	0.025% + 1mV	0.025% + 1mV	5	30	IVA	*
STM 18-32	16.0	20.0	32	115Vac • 127-173Vdc	0.025% + 1mV	0.025% + 1mV	5	30	VI	*
20 Volt										
SLC 20-1	18.0	22.0	1	115Vac • 120-165Vdc	0.3%	0.2%	—	100 (max)	1	$155.00
SLC 20-2	18.0	22.0	2	115Vac • 120-165Vdc	0.1%	0.1%	—	100 (max)	2	205.00
SLC 20-5	18.0	22.0	5	115Vac • 120-165Vdc	0.1%	0.1%	—	100 (max)	3	250.00
SLC 20-7	18.0	22.0	7	115Vac • 120-165Vdc	0.1%	0.1%	—	100 (max)	4	300.00
24 Volt										
SLC 24-1	21.6	26.4	1	115Vac • 120-165Vdc	0.3%	0.2%	—	100 (max)	1	$155.00
SLC 24-2	21.6	26.4	2	115Vac • 120-165Vdc	0.1%	0.1%	—	100 (max)	2	205.00
SLC 24-4	21.6	26.4	4	115Vac • 120-165Vdc	0.1%	0.1%	—	100 (max)	3	250.00
SLC 24-6	21.6	26.5	6	115Vac • 120-165Vdc	0.1%	0.1%	—	100 (max)	4	300.00
SSD 24-8.5	20.0	26.0	8.5	115/220Vac • 255-345Vdc	0.01% + 1mV	0.01% + 1mV	5	20	III	345.00
STM 24-8.5	19.0	25.0	8.5	115Vac • 127-173Vdc	0.025% + 1mV	0.025% + 1mV	5	30	III	350.00
SSD 24-13	20.0	26.0	13	115/220Vac • 255-345Vdc	0.01% + 1mV	0.01% + 1mV	5	20	IIIA	470.00
STM 24-13	19.0	25.0	13	115Vac • 127-173Vdc	0.025% + 1mV	0.025% + 1mV	5	30	IIIA	460.00
STM 24-21	19.0	25.0	21	115Vac • 127-173Vdc	0.025% + 1mV	0.025% + 1mV	5	30	IVA	625.00
SSD 24-22	20.0	26.0	22	115/220Vac • 255-345Vdc	0.01% + 1mV	0.01% + 1mV	5	20	IVB	650.00
STM 24-28	19.0	25.0	28	115Vac • 127-173Vdc	0.025% + 1mV	0.025% + 1mV	5	30	VI	800.00
SSD 24-32	20.0	26.0	32	115/220Vac • 255-345Vdc	0.01% + 1mV	0.01% + 1mV	5	20	VIA	790.00
28 Volt										
SSD 28-7	25.0	33.0	7	115/220Vac • 255-345Vdc	0.01% + 1mV	0.01% + 1mV	5	20	III	$345.00
STM 28-7	24.0	30.0	7	115Vac • 127-173Vdc	0.025% + 1mV	0.025% + 1mV	5	30	III	350.00
SSD 28-11	25.0	33.0	11	115/220Vac • 255-345Vdc	0.01% + 1mV	0.01% + 1mV	5	20	IIIA	470.00
STM 28-11	24.0	30.0	11	115Vac • 127-173Vdc	0.025% + 1mV	0.025% + 1mV	5	30	IIIA	460.00
SSD 28-18	25.0	33.0	18	115/220Vac • 255-345Vdc	0.01% + 1mV	0.01% + 1mV	5	20	IVB	650.00
STM 28-18	24.0	30.0	18	115Vac • 127-173Vdc	0.025% + 1mV	0.025% + 1mV	5	30	IVA	625.00
STM 28-24	24.0	30.0	24	115Vac • 127-173Vdc	0.025% + 1mV	0.025% + 1mV	5	30	VI	800.00
SSD 28-25	25.0	32.0	25	115/220Vac • 255-345Vdc	0.01% + 1mV	0.01% + 1mV	5	20	VIA	790.00
36 Volt										
STM 36-4	29.0	43.0	4.0	115Vac • 127-173Vdc	0.025% + 1mV	0.025% + 1mV	5	30	III	$ *
SSD 36-5	32.0	43.0	5.0	115/220Vac • 255-345Vdc	0.01% + 1mV	0.01% + 1mV	5	20	III	345.00
STM 36-6	29.0	43.0	6.0	115Vac • 127-173Vdc	0.025% + 1mV	0.025% + 1mV	5	30	IIIA	*
SSD 36-8	32.0	43.0	8.0	115/220Vac • 255-345Vdc	0.01% + 1mV	0.01% + 1mV	5	20	IIIA	470.00
STM 36-10	29.0	43.0	10	115Vac • 127-173Vdc	0.025% + 1mV	0.025% + 1mV	5	30	IVA	*
SSD 36-12	32.0	43.0	12	115/220Vac • 255-345Vdc	0.01% + 1mV	0.01% + 1mV	5	20	IVB	650.00
STM 36-14	29.0	43.0	14	115Vac • 127-173Vdc	0.025% + 1mV	0.025% + 1mV	5	30	VI	*
SSD 36-19	32.0	43.0	19	115/220Vac • 255-345Vdc	0.01% + 1mV	0.01% + 1mV	5	20	VIA	790.00
48 Volt										
SSD 48-4	42.0	56.0	4.0	115/220Vac • 255-345Vdc	0.01% + 1mV	0.01% + 1mV	5	20	III	$345.00
STM 48-4	42.0	56.0	4.0	115Vac • 127-173Vdc	0.025% + 1mV	0.025% + 1mV	5	30	III	350.00
SSD 48-6	42.0	56.0	6.0	115/220Vac • 255-345Vdc	0.01% + 1mV	0.01% + 1mV	5	20	IIIA	470.00
STM 48-6	42.0	56.0	6.0	115Vac • 127-173Vdc	0.025% + 1mV	0.025% + 1mV	5	30	IIIA	460.00
SSD 48-10	42.0	56.0	10	115/220Vac • 255-345Vdc	0.01% + 1mV	0.01% + 1mV	5	20	IVB	650.00
STM 48-10	42.0	56.0	10	115Vac • 127-173Vdc	0.025% + 1mV	0.025% + 1mV	5	30	IVA	625.00
STM 48-14	42.0	56.0	14	115Vac • 127-173Vdc	0.025% + 1mV	0.025% + 1mV	5	30	VI	800.00
SSD 48-15	42.0	56.0	15	115/220Vac • 255-345Vdc	0.01% + 1mV	0.01% + 1mV	5	20	VIA	790.00

*Non Stocked Model Consult Factory for Price and Delivery.

Dimensions: (H x W x L) III 3.31 x 5.13 x 9.5 in (84 x 130 x 241 mm), IIIA 3.31 x 5.13 x 14 in (84 x 130 x 355 mm), IVA 4.94 x 7.5 x 10.5 in (125 x 190 x 267 mm), IVB 4.94 x 7.5 x 11.5 in (125 x 190 x 292 mm), VI 4.94 x 7.5 x 14 in (125 x 190 x 355 mm) VIA 4.94 x 7.5 x 16 in (125 x 190 x 406 mm), X 4.94 x 11.25 x 16.5 in (125 x 286 x 419 mm), 1 5.13 x 1.32 x 8.63 in (130 x 33 x 219 mm), 2 5.13 x 1.97 x 8.63 in (130 x 50 x 219 mm), 3 5.13 x 3.44 x 8.63 in (130 x 87 x 219 mm), 4 5.13 x 5.25 x 8.63 in (130 x 133 x 219 mm).

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New Products

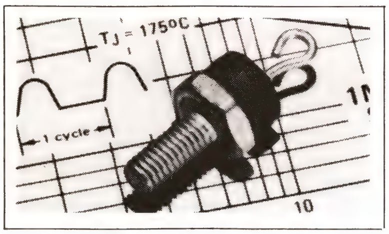
(100). **Electronic Arrays Inc,** 550 E Middlefield Rd, Mt View, CA 94043. Phone (415) 964-4321. **Circle No 244**

BUS TRANSCEIVERS. For bus-interface applications, 8T126 through 8T129 devices feature 3-state outputs on both send and receive buffers and pnp transistors on all inputs. The 8T126 and 8T128 have a 3.5V minimum V_{OH} level on the receiver to accommodate MOS-interface applications. With these units, the send and receive buffers have separate enable inputs. The 8T127 and 8T128 feature full 24-mA drive in both send and receive buffers. They have a common chip enable and a send/receive input. From $1.42 (100). **Signetics,** 811 E Arques Ave, Box 9052, Sunnyvale, CA 94086. Phone (408) 739-7700.

Circle No 245

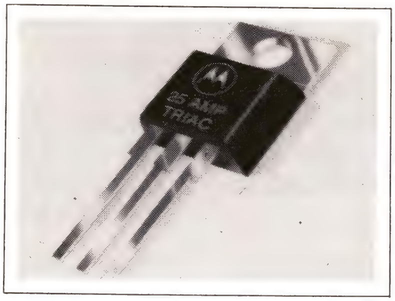
GaAs FET. A dual-gate device for applications from 2 to 12 GHz, Model LND832 offers 10-dBm power output at 10 GHz with a 4V drain bias. It can operate at drain biases as high as 10V. Made from vapor-phase, multilayer epitaxial GaAs, this unit uses recessed gates and n+ contact layers to provide high breakdown voltages and high burnout resistances. Available as a 23×17×5-mil chip, the device can be supplied on carriers. $150. **Raytheon Co,** Special Microwave Devices Operation, 130 2nd Ave, Waltham, MA 02154. Phone (617) 899-8400, ext 4749.

Circle No 246



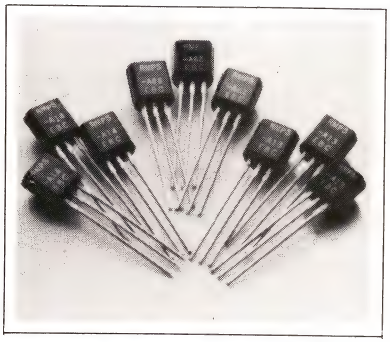
12A RECTIFIERS. By housing a plastic button rectifier on a metal stud, the 1N1199C through 1N1206 Series of 12A rectifiers offer the capabilities of all-metal units, but at a reduced price. They withstand current surges up to 400A at 175°C junction temperatures. The package meets the EIA DO-4 (DO-203AA) outline. The 50 to 600V series features two copper heat sinks soldered to each side of the die. From $0.60 (100). **Motorola Semiconductor Products Inc,** Box 20912, Phoenix, AZ 85036. Phone (602) 244-4624. **Circle No 247**

New Products



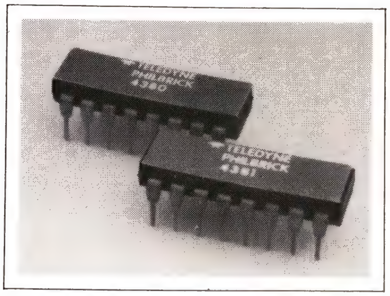
HIGH-CURRENT TRIACS. MAC223/223A devices come in plastic TO-220 packages and feature 25A (rms) and 250A (surge) current capacities. Designed primarily for full-wave ac-control applications, some units can handle loads greater than 10 kW. MAC223 devices are 3-quadrant triggering; MAC223A units, 4-quadrant triggering. A 200V unit from this 100 to 800V series controls 2.5 kW; an 800V device controls more than 10 kW (MAC223-10). From \$1.63 (100). **Motorola Semiconductor Products,** Box 20912, Phoenix, AZ 85036. Phone (602) 244-6437.

Circle No 248



SMALL-SIGNAL TRANSISTORS. This extremely high-current-gain transistor series is offered in standard TO-92 plastic packages. Both npn and pnp types are monolithic, double-diffused, silicon epitaxial planar Darlington devices. Standard TO-18 and TO-5 lead forming is available. All devices can dissipate 625 mW and handle input currents up to 500 mA. The series includes MPS-A12/14, MPS-5305/8 2N6426/27, and 2N5305/8 npn devices and MPS-A62/64 pnp units. \$110 to \$120 (1000). Delivery, 8 to 12 wks ARO. **R-Ohm Corp,** 16931 Milliken Ave, Irving, CA 92714. Phone (714) 546-7750 or (312) 843-0404.

Circle No 249



LOG/ANTILOG AMPS. Model 4380, a monolithic logarithmic amplifier, handles six decades of input current or three decades of voltage input. Fully temperature compensated, it nominally provides 1V of output change for each decade of input change. Scale factor, reference current and offset voltage are externally adjustable. Typical errors are 0.2% FS (I_{IN}=1 nA to 1 mA). The unit requires ±15V supplies. An antilog amp (4381) is also available. Each device costs \$37.50. **Teledyne Philbrick,** Allied Dr at Rte 128, Dedham, MA 02026. Phone (617) 329-1600.

Circle No 250

THE FIVE BEST WAYS TO ISOLATE A PROBLEM.

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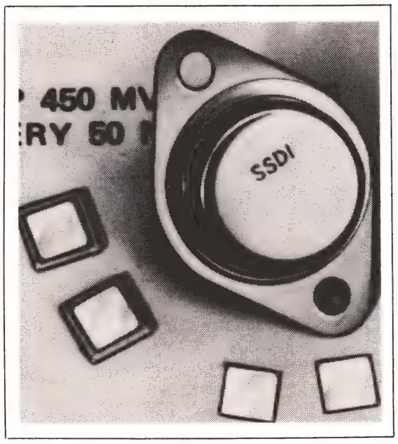
New Products



FAST RECTIFIERS. HSR-7CD devices are available as bare chips, chips on molybdenum pedestals or packaged in TO-3 cases. The series has peak repetitive reverse-voltage ratings from 20V to 150V and rms reverse-voltage ratings from 15V to 110V. Reverse recovery time of 40 nsec and full-current operation to 130°C suit them for replacing Schottky diodes. Average full-cycle forward-voltage drop equals 0.45V; maximum instantaneous drop is 0.9V. Maximum dc reverse leakage is 500 μA, while peak repetitive surge current is 300A. From \$6.75 (chips), \$7.05 (chips on pedestals) and \$8.05 (TO-3) (100). **Solid State Devices Inc,** 14830 Valley View Ave, La Mirada, CA 90638. Phone (213) 921-9660. **Circle No 251**

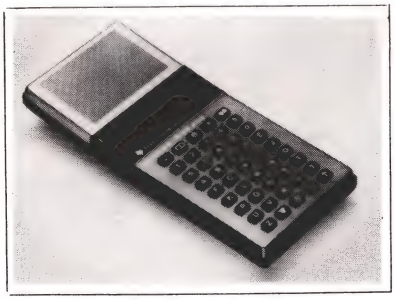
PHOTODIODE/OP AMP. In a standard 14-pin DIP, the HUV-2000B packs a hybrid op amp and a UV-enhanced, large-area (24 mm^2) photodiode. The diode has a typical sensitivity at 254 nm of 3×10^7V/W and covers the spectral range of 200 to 1150 nm. The package, requiring only power and an external trimming pot for nulling offset voltages, minimizes noise pickup and has an NEP at 20 Hz of 2.6×10^{-13}W/$\sqrt{\text{Hz}}$. \$95. **EG&G Electro-Optics,** 35 Congress St, Salem, MA 01970. Phone (617) 745-3200. **Circle No 252**

32-BIT COUNTER. Capable of counting at up to 10 MHz, Model LS7060 32-bit binary up counter presents its information in 8-bit groups, least significant byte first, to the eight 3-state outputs at clock rates up to 1 MHz. Successive bytes of data are enabled at the outputs on each positive transition of a SCAN pulse. A cascading feature permits the attachment of any number of LS7060s to the same bus. Information can still be read out in successive bytes in this mode. In an 18-pin DIP, the NMOS chip costs \$5.05 (1000). **LSI Computer Systems Inc,** 1235 Walt Whitman Rd, Melville, NY 11717. Phone (516) 271-0400. **Circle No 253**

SWITCHERS. Available in TO-3 and plastic TO-220AB packages, Switchpower power transistors possess excellent high-current, fast-switching characteristics. TO-3-housed units have $V_{CEO(SUS)}$ ratings of 300 to 400V in 15, 7.5 and 5A current ranges. Typical inductive fall times are less than 300 nsec for these units (D64VS Series). The D44TD and D44TE Series come in TO-220AB packages and are I_C rated at 2 and 4A, respectively. From \$7.90 (1000, D64VS Series). **General Electric Co,** W Genesee St, Box 44, Auburn, NY 13021. Phone (315) 253-7321, Ext 520. **Circle No 254**

COMPUTERS & PERIPHERALS

TALKING TRANSLATOR. Utilizing speech synthesis and equipped with solid-state electronic modules for English, French, German and Spanish, this language translator forms phrases by linking together its spoken vocabulary words. Each module contains about



1000 words, half of which are spoken and displayed and half only displayed.

The unit provides five basic functions: generation of 25 preprogrammed common phrases, linking of preprogrammed partial phrases, translate mode, memory-learn mode (user-chosen pronunciation and translation drill) and learn mode (programmed drill). Vocabulary categories include 65 basic phrases, basic adjectives, foods, mail, travel and time.

Typical preprogrammed phrases, which include "I am lost," "Can you show me?," "Speak a little more slowly" and "I am hungry," plus partial phrases such as "Do you have______?," expand the device's versatility. Phrases are accessed by keying-in numerical codes that correspond to listings in an accompanying pocket-sized phrase-code book. Translator, approximately $250; modules, approximately $50 each (suggested retail). **Texas Instruments Inc,** Consumer Relations, Box 53, Lubbock, TX 79408. Phone (806) 747-3737.

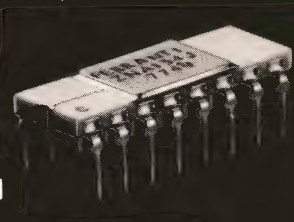
Circle No 288

INDUSTRIAL μCs. For use in networked computer control systems, the RacPac family fits in all types of 19-in. racks. Its primary member is the PCS 3935A ($2995), which contains an integral 5-in. CRT, a panel-mounted keyboard with an external keyboard connector, a panel lock-switch that controls power and keyboard-switch enable and disable, a hardware reset/restart switch and an attention switch. You can also specify the Z80-based PCS 1780A CPU board, the PCS 1712A board for CRT and keyboard support and the PCS 1745A, a battery-backed-up real-time clock and ROM extender. Analog and digital I/O subsystems and software round out the family. **Process Computer Systems Inc,** 750 N Maple Rd, Saline, MI 48176. Phone (313) 429-4971. **Circle No 289**

8-IN. HARD-DISC DRIVE. Model 101 stores 11.7M bytes on two fixed discs. It exhibits a 20-msec track-to-track access time and 70-msec average access time; average latency equals 10.1 msec. Weighing 20 lbs, the drive measures 8.55×4.38×14 in.; power requirements are ±5 and 24V dc. $1560 (100). Shipments will begin in the first quarter of 1980. **Memorex Corp,** San Tomas at Central Expressway, Santa Clara, CA 95052. Phone (408) 987-2200.

Circle No 290

Dual, 525/625 Line TV Sync-Pulse Generator.



The Ferranti ZNA134J provides all the sync pulses necessary for b&w TV in both EIA and CCIR line standards.

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- Vertical/horizontal resets for immediate sync-lock
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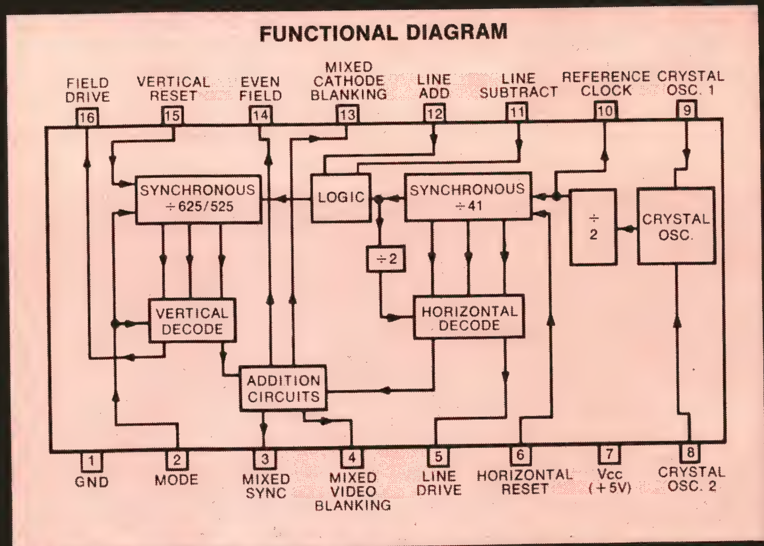
- Field reference output



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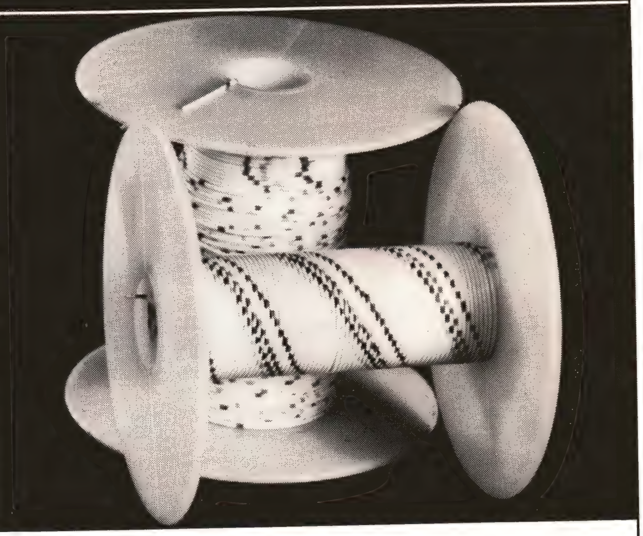

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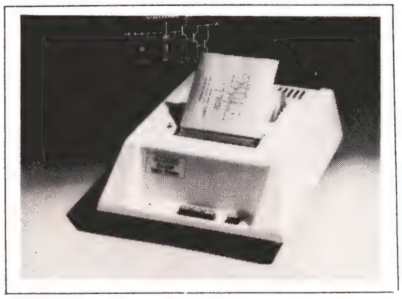
New Products



VIDEO PRINTER reproduces (by means of a 24-wire matrix printhead) any monotone graphic or alphanumeric CRT display in any language and character font without the need for a hardware or software interface to the CRT. Its video controller connects directly to the video signal of any raster-scan CRT display and samples information on the screen, thus dispensing with the need for conventional interfacing and standard codes. The EX-850 comes as a complete stand-alone package including case, power supply, video-printer controller, low-paper detector, bell and paper-roll holder. $1250 (single qty); $937 (100). Delivery, 45 days ARO. **Axiom Corp,** 5932 San Fernando Rd, Glendale, CA 91202. Phone (213) 245-9244.

Circle No 291

DIGITIZER. The Micro Datatizer processes and converts graphic data into a display or printout of X-Y values, length, volume and other calculated physical or chart values. It can also send processed or raw graphic data to host systems for recording, computer data-base processing or interactive display. You get a digitizing tablet, an interchangeable crosshair or pen cursor and a controller housing the microprocessor subsystem; tablets come in eight standard sizes from 6×6 to 42×60 in. with resolutions of 0.001 or 0.01 in. Approximately $8000 for a unit with a 30×36-in. tablet. **GTCO Corp,** 1055 First St, Rockville, MD 20850. Phone (301) 279-9550.

Circle No 292

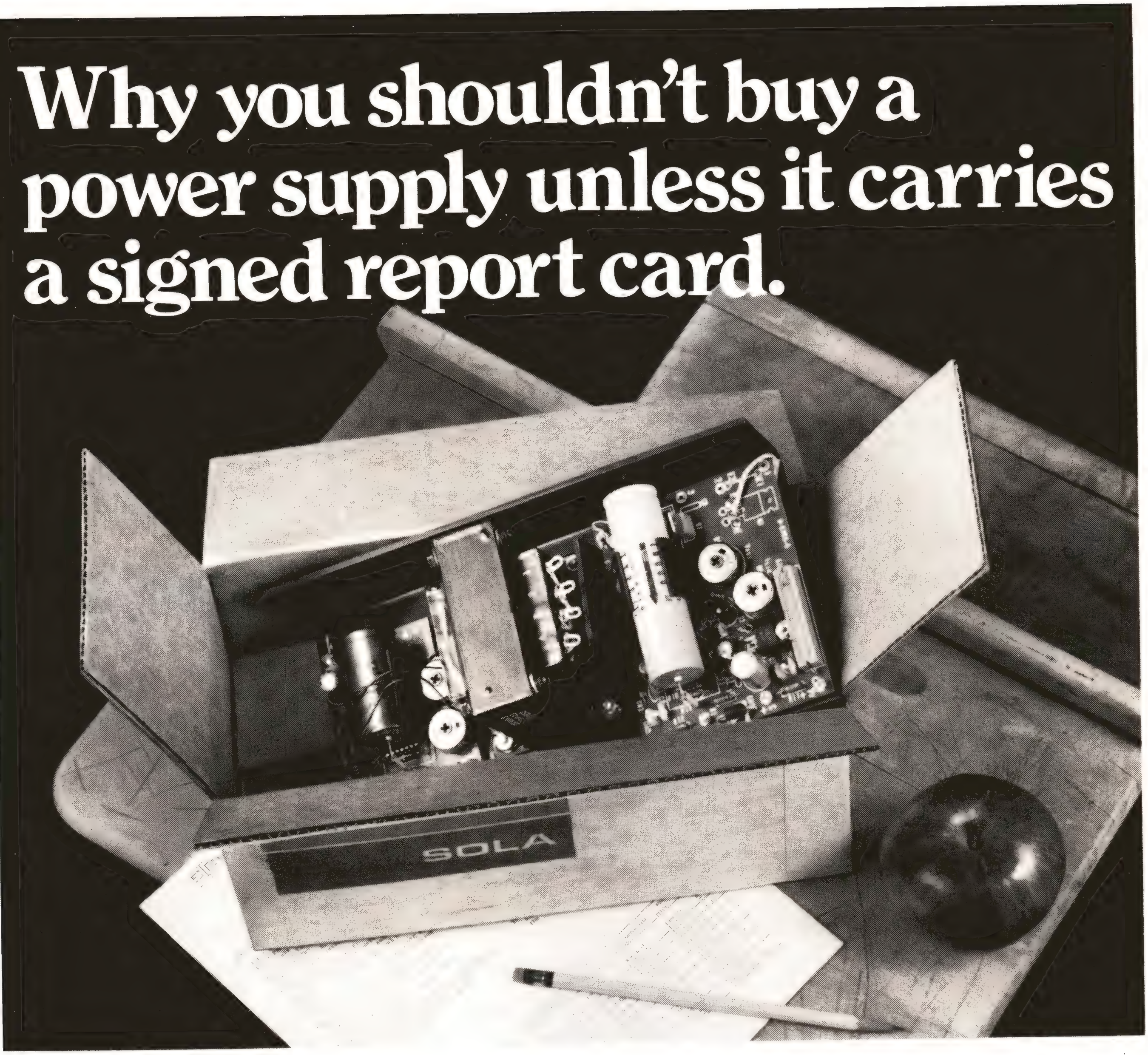
PROM PROGRAMMERS. These Z80-controlled universal PROM programmers serve production (Model MPP 80-P) service (-S) and engineering (-E) applications; they accommodate all UV-erasable PROMs and major families of bipolar devices. Common features include 32k-bit internal RAM (64k optional), hex keyboard, graphic display and compact packaging. All versions offer a gang module for programming up to eight PROMs simultaneously. $1495, $1995 and $2495, respectively, for production, service and engineering units; personality modules. $325 each. **Kontron Electronic,** 700 S Claremont St, San Mateo, CA 94402. Phone (415) 348-7291.

Circle No 293

DEVELOPMENT PACKAGE. You can convert Apple II computers into software-development systems for 6502 μPs with this hardware/software package. Designed to run on a system equipped with 48k of RAM and mini-floppy diskette, the package includes an EPROM programmer, ROM-based monitor and debugger, diskette-based editor and assembler and a diskette utilities package. $995. **Micro Power Designs Inc,** Box 393, Alief, TX 77411. Phone (713) 499-5402.

Circle No 294

Why you shouldn't buy a power supply unless it carries a signed report card.



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At Sola, our numbers represent *minimal* performance standards. To guarantee that our power supplies perform at least as well as we say they will, we test them thoroughly before they leave the factory. That's why you find a signed and dated test report on each one.

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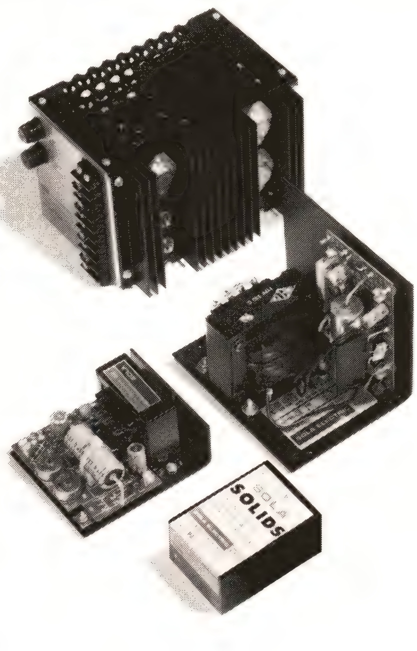

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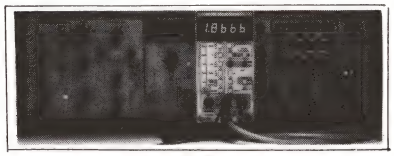
New Products

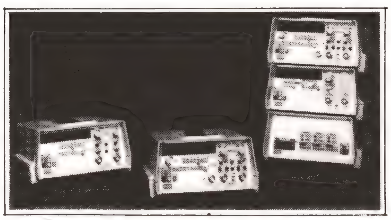
INSTRUMENTATION & POWER SOURCES



7-FUNCTION DMM PLUG-IN. Part of its manufacturer's TM-500 family, the 4½-digit DM 501A, to be introduced at Wescon, contains both front-panel and rear-connector input provisions.

The instrument's full-scale-range values span 200 mV to 1000V dc with 10-μV resolution, 200 mV to 500V true-rms ac (20 Hz to 20 kHz), −40 to +40 dBV or dBm (add the reading—up to +19.9 dB—to range setting), 20 μA to 2A ac or dc, 200Ω to 20 MΩ (HIGH/LOW excitation), and −62 to +240°C. Basic reading accuracy equals 0.06% at full scale on dc volts.

For temperature measurements, the entire probe plus cable can be immersed in liquids up to 140°C; low thermal mass permits fast readings. DM 501A with temperature probe, $555; without temperature-measurement capability, $430. **Tektronix Inc**, Box 500, Beaverton, OR 97077. Phone (800) 547-1512. **Circle No 295**



COUNTER FAMILY. Several common features of these latest Fluke offerings deserve mention. In particular, they offer quiet hybrid high-impedance thick-film front ends (made in-house), complete internal stainless-steel RFI shields, ovenized oscillators (optional) that can be used with battery power, and compatibility with the IEEE bus when interfaced via a translator.

Model 7250A, a low-cost universal 80-MHz counter/timer, provides autoranging and input noise filtering; it handles frequency, period, period average, time interval, totalizing, ratio and counts per minute. You can order such options as battery powering, TCXO or oven crystal, and IEEE-488 interface. $675.

Models 7260A and 7261A, both universal 125 MHz counter/timers, carry a host of features. Both provide complete signal conditioning and contain a 100-kHz low-pass filter. The 7260A provides a 100-nsec clock, while the 7261A's is 10 nsec. $850 for 7260; $995 for 7261.

Finally, Model 7220A delivers 1300-MHz performance (Channel A—5 Hz to 125 MHz, high-impedance direct count; Channel B—50 to 1300 MHz, 50Ω prescaled). It provides burst capability, manually selectable 100-Hz to 0.1-Hz resolution and a 9-digit display. Less than $800. Delivery, 60 days ARO. **John Fluke Mfg Co Inc**, Box 43210, Mountlake Terrace, WA 98043. Phone (206) 774-2322. **Circle No 296**

ELECTRO-OPTIC MODEM. The CEO-M-06M is designed for serial transmission in a simplex or duplex mode from dc to 6M bps. Offering TTL compatibility, the link operates over distances up to 1.5 km with a BER of 10^{S9}. Standard units are supplied with connectorized fiber-optic cable to optimize system performance. The modem operates over a 0 to 40°C range and measures 8.9×20.3×25.4 cm (19-in. rack-mounting model available). **Canstar Communications,** 1240 Ellesmere Rd, Scarborough, Ontario MIP 2X4, Canada. Phone (416) 293-9722. **Circle No 297**

MICROWAVE LEAK DETECTOR. Passive, self contained and simple to use, Model 748 indicates radiation levels above the prescribed US safety standard of 5 mW/cm² at a distance of 2 inches. Radiation received by an integral microwave dipole energizes the LED indicator, eliminating the need for battery powering or moving parts. The device measures 7½ in. long. $15.95. **Metrifast,** 51 S Denton Ave, New Hyde Park, NY 11040. Phone (516) 328-3333. **Circle No 298**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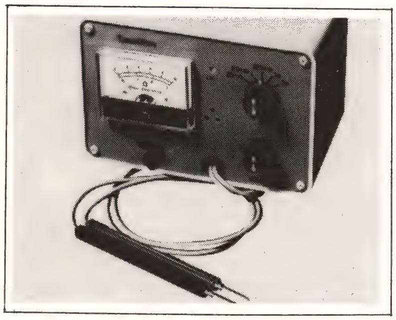
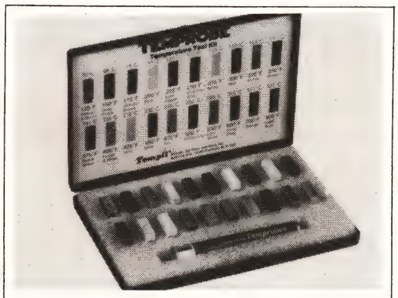
New Products

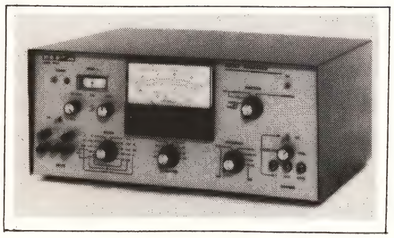


TONE MILLIOHMMETER. Providing both a meter readout and an audible-tone output that varies linearly from 30 Hz to 4 kHz between full-scale deflection and zero-ohms indication, the Model 3PX200 Toneohm lets its user pinpoint hidden shorts to within 5 mm of their actual location. Typically, the injection-signal level is 5 mV at 1 kHz; the use of Kelvin probes minimizes lead loss. Five meter ranges cover 30 mΩ to 3Ω FS. $595. **Three Phoenix Test Inc,** 21639 N 14th Ave, Phoenix, AZ 85027. Phone (602) 242-6300. **Circle No 299**

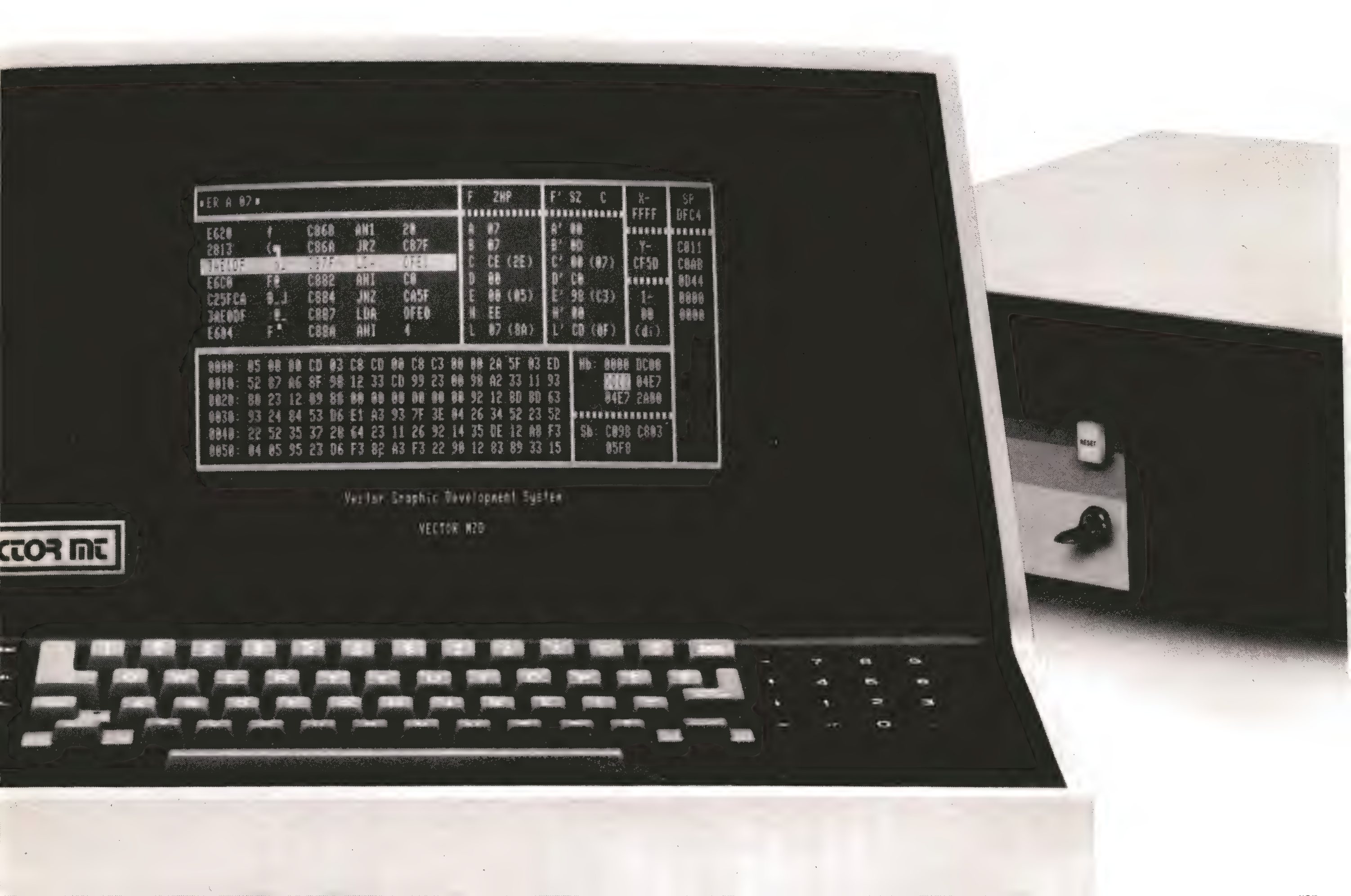


TEMPERATURE TEST KIT. Although only pocket sized, the Temprobe kit contains 20 temperature-indicating crayons that cover 125 to 800°F (52 to 427°C). Each crayon melts at a specific temperature, guaranteed within ±1%. A special metal holder/marker makes application easy. $10. **Tempil,** Hamilton Blvd, South Plainfield, NJ 07080. Phone (201) 757-8300. **Circle No 300**

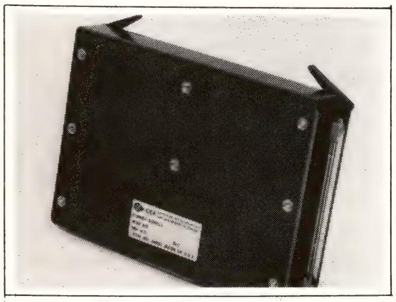
SYNTHESIZER. Low noise, AM/FM/PM capability and an IEEE-488-bus option highlight the 300-kHz to 650-MHz Model 460. Phase noise specs at −134 dBc/Hz at 12.5 kHz from the carrier, and the noise floor holds at −145 dBc/Hz. A μP controls levels and programs all modulation-related functions plus an auto-test capability. $13,850. Delivery, 90 days ARO. **Ailtech,** Div of Cutler-Hammer, 2070 Fifth Ave, Ronkonkoma, NY 11779. Phone (516) 588-3600. **Circle No 301**



AUDIO ANALYZER. Model 7000 combines in one package wow, flutter and speed (drift) analyzers; an audio oscillator; an auto-nulling total-harmonic-distortion analyzer; an ac voltmeter; a dB meter and an output meter. It also features differential inputs and 2-channel capability. Optional 100W stereo 8Ω loads provide further versatility. $1295. **BPI Audio Test Instruments,** 7853 Balboa Ave, San Diego, CA 92111. Phone (714) 279-3344. **Circle No 302**

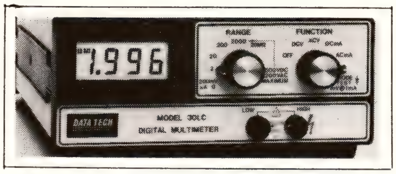

Vector Graphic Development System
VECTOR MZD
RESET

New Products



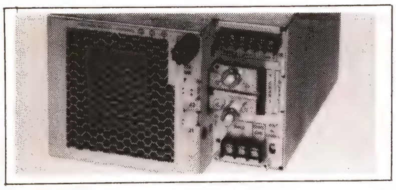
FOUR-OUTPUT SWITCHERS. Designed for airborne μPs but suited to any severe environment, this plug-in unit provides outputs of +5V/15A, +12V/2A, −5V/1A and −12V/1A (with optional 15V outputs replacing 12V). Input can be 115 or 230V±10%, 47 to 440 Hz or 28V dc. All outputs maintain a total regulation band of 3%, and all models furnish protection against overcurrent, short-circuit, overvoltage and reverse-voltage conditions. $675 (100). **CEA,** Div of Berkleonics Inc, 1 Aerovista Park, San Luis Obispo, CA 93401. Phone (805) 544-5454. **Circle No 303**

°C/°F THERMOMETER. A bright LED display reads out temperatures from −200 to +750°C (−328 to 1382°F), providing 0.1° resolution from −199 to +199°C and 1° resolution outside that span. Accuracy equals 0.3%. Model TT 4000DS operates from either its built-in rechargeable battery or a 110V, 60-Hz line. An aluminum case protects against external magnetic fields, and the unit switches off when battery voltage drops below operating level. $755, plus $160 for probe. **Ever Ready Thermometer Co Inc,** 401 Park Ave South, New York, NY 10016. Phone (212) 684-2155.
Circle No 304

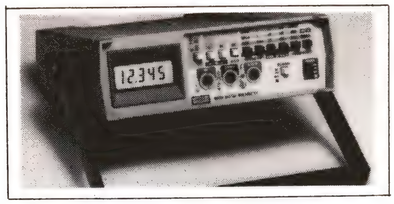


LC-DISPLAY DMM. Because it uses a 3½-digit liquid-crystal display and single-chip LSI for the A/D conversion, the six-function Model 30LC can be powered for up to 2400 hrs by four alkaline D cells. Features include autozero and polarity, a low-battery indication on the display and overrange blanking. $159. **Data Tech,** Div of Penril Corp, 2700 S Fairview St, Santa Ana, CA 92704. Phone (714) 546-7160.
Circle No 305

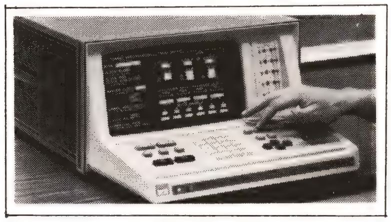
New Products



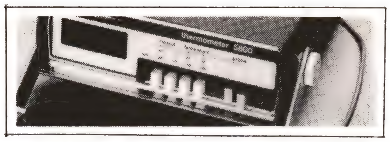
ECL SWITCHERS. Models PM2677A and PM2678A furnish up to three outputs specifically designed to meet ECL needs. Typical main output is −2V/200A or −5.2V/150A; second-channel output, −2V/30A or −5.2V/30A; third-channel output, 5 to 28V/5 or 7A. Maximum power runs 750W for the 2677A, 850W for the 2678A. Input ranges span 92 to 138V or 184 to 250V rms but operation holds to 80 or 160V. Full rating applies to +50°C. $793 for the 2677A, $866 for the 2678A. **Pioneer Magnetics Inc,** 1745 Berkeley St, Santa Monica, CA 90404. Phone (213) 829-6751. **Circle No 306**



μP-ENHANCED DMM. The 4½-digit Model 8050A furnishes both offset and dBm capabilities usually found only in higher priced units. Features include 5 ranges each for ac and dc voltage and current, 10 dBm ranges, six resistance ranges and two conductance ranges. Ac ranges are true rms, with frequency coverage from 45 Hz to 10 kHz. $329. **John Fluke Mfg Co Inc,** Box 43210, Mountlake Terrace, WA 98043. Phone (206) 774-2322. **Circle No 307**



LOGIC-STATE ANALYZER. Multiphased, qualified clocks enable Model 1610B to quickly and easily perform analyses of multiplexed buses. The clocking capability furnishes three data-capture modes: 32 bits, 16/16 bits and 16/8/8 bits. The instrument can also be set to display the contents of its memory even when all trigger conditions are not satisfied or a system clock fails. $12,500. **Hewlett-Packard Co,** 1507 Page Mill Rd, Palo Alto, CA 94304. Phone (415) 856-4234. **Circle No 308**



DIGITAL THERMOMETER. Power for the portable Thermometer 5800 can be from either its internal rechargeable battery pack or 115/230V ac (by means of a furnished battery charger). The instrument accepts two Series 700 thermistor probes, reading out the temperature from either of four pushbutton ranges of −30 to +50° or 0 to 100°C, and −22 to +122° or 32 to 199°F. Resolution equals 0.1°. $295; probes, $15 to $35. **Omega Engineering Inc,** Box 4047, Stamford, CT 06907. Phone (203) 359-1660. **Circle No 309**

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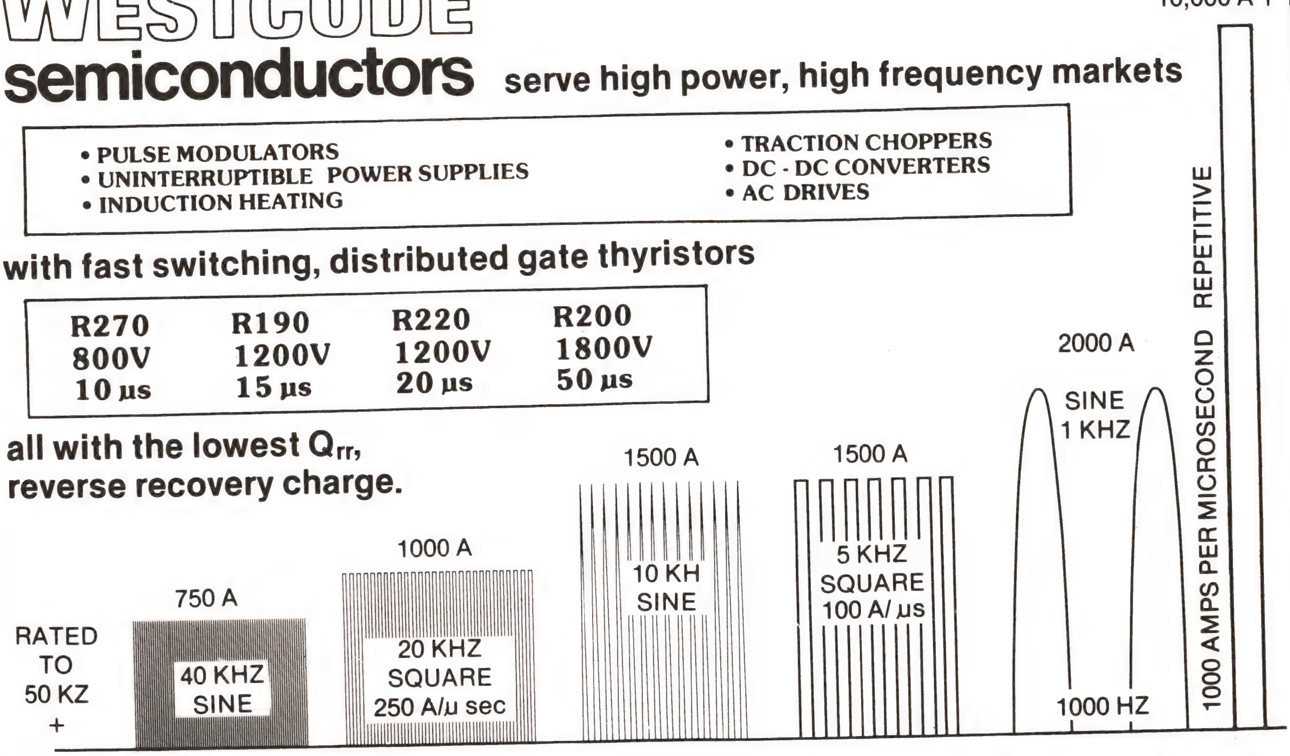

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For more information, Circle No 141

New Products

SOLDERABILITY TESTER. The difficult job of testing solderability and obtaining objective, quantitative results has been taken on by a µP-controlled system from Multicore Solders. The basic device (with its various interchangeable attachments) tests the solderability of plated-through holes (PTHs), metal-clad laminates, pc boards and electronic component terminations—using the meniscus, edge dip, globule or PTH test methods. $5500 base price; $10,975 complete. **Multicore Solders,** S Service Rd, Westbury, NY 11590. Phone (516) 334-7450. **Circle No 310**

SPECTRUM RECORDER. Model 4406A provides automatic on-line digital recording and/or plotting of real-time frequency spectra for noise/vibration data logging, 3-D time-history recording and QC record keeping. The system can record up to 1500 400-line spectra (or a larger number of ⅓ or 1/1 octave spectra) on each digital tape cartridge. All records include the setup and calibration status of the spectrum analyzer, so data recalled and/or plotted at a later time retain their meaning. Recall for automatic comparison or plotting can skip to selected tag numbers on the tape, rather than access only a preset sequence of file numbers. $25,450. **Nicolet Scientific Corp,** 245 Livingston St, Northvale, NJ 07647. Phone (201) 767-7100. **Circle No 311**

100V/2A PULSE GENERATOR. Serving needs intermediate between those handled by conventional pulse generators and those that require high power, Model PG-13D delivers output pulse voltage to ±100V or pulse current to ±2A. In addition to internal, external, single-shot and gated PRF operation, the generator provides a pulse of fixed delay or two pulses with variable delay between them. Repetition rate is from one-shot to 20 MHz; pulse width can be from 20 nsec to 500 msec. **Velonex,** 560 Robert Ave, Santa Clara, CA 95050. Phone (408) 244-7370. **Circle No 312**

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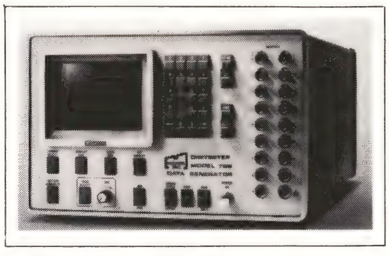
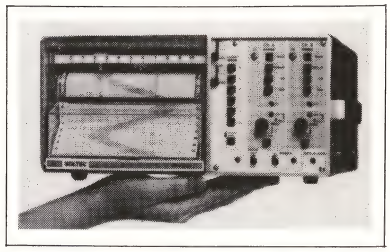
New Products



DATA GENERATOR. Latest in a line of digital data pattern generators, Model 725 features a built-in CRT and key pads that enable the operator to enter patterns in any of a number of formats. Data can be entered and displayed in binary, octal and hexidecimal table formats, or as a serial or parallel timing diagram. $5500. **Moxon Inc,** 2222 Michelson Dr, Irvine, CA 92715. Phone (714) 833-2000. **Circle No 313**



DUAL-PEN RECORDER. Each of Model VP-66723C's two pens writes full scale on 120-mm fan-fold paper. The portable unit operates on ac/dc or internal battery, has 8 ranges (10 mV to 100V FS) and 12 chart speeds (0.5 cm/hr to 16 cm/min) and responds to full scale in 0.5 sec. Other features such as a built-in battery charger, pushbutton event markers, and an integral 50-mV calibration source add to versatility. $1350. **Soltec Corp,** 11684 Pendleton St, Sun Valley, CA 91352. Phone (213) 767-0044. **Circle No 314**

DUAL HIGH-POWER SWITCHER. By furnishing two 400W outputs at 2, 3, 5, 12, 15, 18, 21, 24, 28 or 48V dc and a third channel at 2, 3, 5, 12 or 15V dc (its output subtracts from the 400W rating of the second channel), Model PM2809 suits many applications. Total power must not exceed 800W. Specs show input of 184 to 260V (47 to 63 Hz), regulation through line dips to 166V, 30-msec holdup, full output to 50°C, remote sensing, no overshoot and protection against overvoltage, overtemperature and reverse voltage. $1075. Delivery, 16 wks ARO. **Pioneer Magnetics,** 1745 Berkeley St, Santa Monica, CA 90404. Phone (213) 829-6751. **Circle No 315**

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AD7525. THE WORLD'S FIRST SINGLE CHIP DIGITAL POT.

Anyone who uses expensive and cumbersome 10-turn pots or thumbwheel-switch voltage dividers will welcome the accuracy, reliability and ease of use of the AD7525. It's a new solution to an old problem. That is the setting of AC or DC signal levels digitally and usually remotely. The AD7525 replaces the noise, inaccuracies and expense with a reliable, economical monolithic CMOS 3½ digit BCD digitally-controlled potentiometer. The world's first single chip digital pot and the only high resolution CMOS multiplying DAC available with BCD coding.

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Only $8.50 in 1000's (AD7525KN). It means you can build an entire attenuator circuit for about $22. That includes the AD7525KN, an op amp, the trim-pot (which allows gain accuracy to be precisely set), resistors and the thumbwheel-switch assembly. That's a lot less money for a lot more performance and reliability than the "old" way.

But prove it to yourself. Check out one of the six available performance grades of the AD7525, the world's first single chip digital pot. Call Doug Grant or Don Travers, (617) 935-5565. Or write Analog Devices, P.O. Box 280, Norwood, MA 02062.

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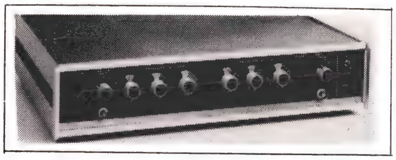
For more information, Circle No 147

New Products



PROGRAMMABLE FILTER. Named Brickwall because of its 115 dB/octave rolloff on both sides of the passband, Model 751A lets you set both center frequency and bandwidth anywhere in the 1-Hz to 100-kHz spectrum. As an option, remote digital programming of cutoff frequencies, prefiltering and postfiltering can be provided through a buffered parallel-input BCD interface (IEEE interface optional). This 7th-order Cauer Elliptic active filter has only 0.3-dB passband ripple. $3300. **Rockland Systems Corp,** Rockleigh Industrial Park, Rockleigh, NJ 07647. Phone (201) 767-7900. **Circle No 316**

FIBER-OPTIC TEST METER. You can use Model FPM-1 to measure source optical power, fiber-optic-cable output power and both detector responsivity and dark currents under biased conditions. Average-optical-power measurements cover 20 nW to 2 mW (between 500 and 1000 nm); current measurements span 2 nA to 200 μA. Accuracy runs ±5% for power, ±0.5% for current—read on a 3½-digit LCD. Power-measurement sensing heads are available for many standard connectors. $499, with one head and the adapter for detector measurements. Delivery, 6 wks ARO. **Radiation Devices Co Inc,** Box 8450, Baltimore, MD 21234. Phone (301) 628-2240. **Circle No 317**

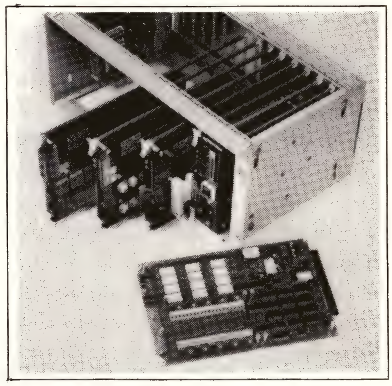
PHOTOMETER/RADIOMETER. With a spectral range from 220 to 1800 nm and light-detection capability from below 1 pW to above 2W, Model 88XL furnishes direct linear readout of radiant power in nW, μW and mW. It also makes direct linear photo-optic measurements, using interchangeable sensor heads that contain the NBS optical-calibration factor. Readout is on a 3½-digit LCD; a 34-pin edge connector brings out analog and digital signals for recording. $665; silicon-sensor head, $175. **Photodyne Inc,** 5356 Sterling Center Dr, Westlake Village, CA 91361. Phone (213) 889-8770. **Circle No 318**

UPSs. Four new uninterruptible power supplies furnish both logic and battery-charging output. Each unit provides smooth crossover upon line dropout, delivers full output to 71°C without derating and features tight regulation of both outputs. Models UPS12-5S3000 and UPS24-5S3000 ($169.95) each furnish 5V/3A for logic, plus 13.5V/2A and 27V/1A (respectively) for battery charging; similarly Models UPS12-5S6000 and UPS24-5S6000 ($179.95) deliver 6A for logic, plus 13.5V/0.8A and 27V/0.4A (respectively) for charging. Delivery, 6 to 8 wks ARO. **Semiconductor Circuits Inc,** 218 River St, Haverhill, MA 01830. Phone (617) 373-9104. **Circle No 319**

COMPUTER-SYSTEM SUBASSEMBLIES

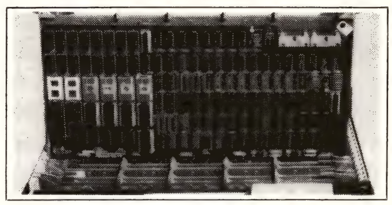
DATA-ACQUISITION SYSTEMS. Combining a 12-bit sample/hold circuit and a 12-bit ADC with either a software-programmable-gain (DAS1151) or resistor-programmable (DAS1150) instrument amp, these units provide guaranteed 12-bit performance at up to 25-kHz throughput with unity gain and ±1-LSB maximum overall error. DAS1150, $199; DAS1151, $249. **Analog Devices Inc,** Box 280, Norwood, MA 02062. Phone (617) 329-4700.

Circle No 320



I/O TERMINAL. The SE100 measures, digitizes, isolates and transmits industrial-process data to computers, terminals and modems, as well as completing control loops to isolated DACs and switch closures. Featuring remote self calibration, automatic cable-break protection and complete optical isolation, it handles a variety of sensor and data interfaces. From $1490. **San Diego Instrument Laboratory,** 7969 Engineer Rd, San Diego, CA 92111. Phone (714) 292-0646.

Circle No 321

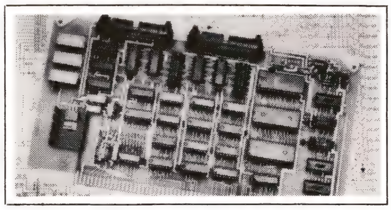


STATISTICAL MULTIPLEXER. Compatible with any Unibus-based computer system, the 205/11 takes multiple data streams from the host computer and concentrates them onto one bit-serial trunk link. One of these boards supports up to 128 terminals, thus replacing a host-end multiplexer and up to 16 DEC DZ-11 asynchronous-terminal interface boards. From $4000. **Digital Communications Associates Inc,** 135 Technology Park, Atlanta, GA 30092. Phone (404) 448-1400. **Circle No 322**

DMA CONTROLLER. For use with Data General Eclipse computers, the Data Channel controller allows you to operate and program all popular high-speed line printers exactly as you would a DG printer. This 1-board unit includes provisions for a horizontal-tab memory feature, printer VFU and optional 3000-ft-line drivers. $1995. **MDB Systems Inc,** 1995 N Batavia St, Orange, CA 92665. Phone (714) 998-6900. **Circle No 323**

New Products

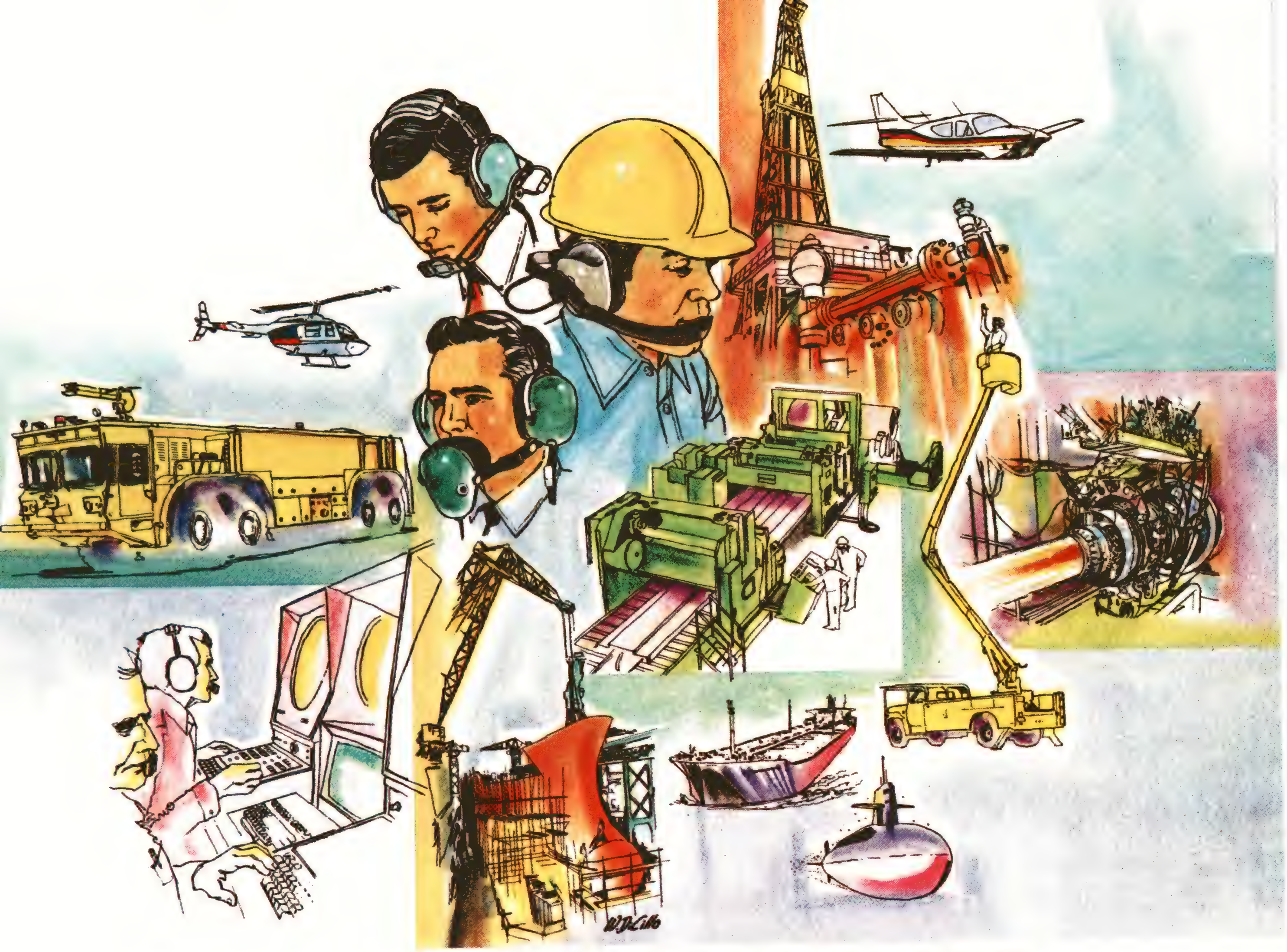
VIDEO DIGITIZER. Under program control, the FG-01 quantizes a video source to form a 256×256-element image of either 4, 6 or 8 bits per pixel. This board then loads the image data into the manufacturer's RGB-256 video-refresh board. Once digitized, the live image can be frozen on command, allowing full computer access. Less than $800. **Matrox Electronic Systems Ltd,** 5800 Andover Ave, Montreal, QUE H4T 1H4, Canada. Phone (514) 735-1182.
Circle No 324



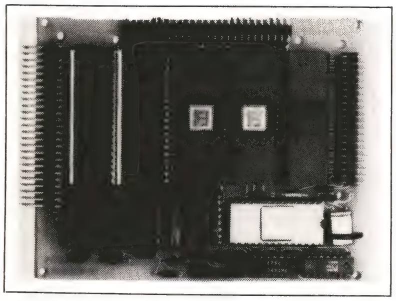
I/O BOARD. Featuring three serial-I/O ports, the Bitstreamer II interfaces with most terminals, printers, readers and punches. Universal synchronous/asynchronous receiver-transmitters implement two parallel input and output ports, as well as the serial ports. By jumper option, the board can generate interrupt requests. $235. **Vector Graphic Inc,** 31364 Via Colinas, Westlake Village, CA 91361. Phone (213) 991-2303. **Circle No 325**

STATIC-RAM BOARDS. The MR 80 family of Multibus-compatible boards comes in both CMOS and NMOS series. CMOS units provide 8k, 16k or 32k 9-bit bytes of memory and include parity-generation/checking circuits, power-monitoring provisions, battery-status indicator and battery charger. NMOS units contain either 16k or 32k bytes with parity checking/generation optional. From $825 for NMOS; from $1200 for CMOS. **Comark Corp,** 257 Crescent St, Waltham, MA 02154. Phone (617) 894-7000. **Circle No 326**

DACs. The ZDA1800 provides 18-bit resolution and a 0.2-ppm/°C nonlinearity temperature coefficient, while the ZDA1600 furnishes 16-bit resolution and 0.4-ppm/°C stability. Interchangeable with Analog Devices' DAC1138, the ZDA1800 settles voltage and current values in 2.5 and 10 µsec, respectively. The ZDA1600 replaces the DAC1136. ZDA1600, $275; ZDA1800, $775. **Zeltex Inc,** 940 Detroit Ave, Concord, CA 94518. Phone (415) 686-6660.
Circle No 327

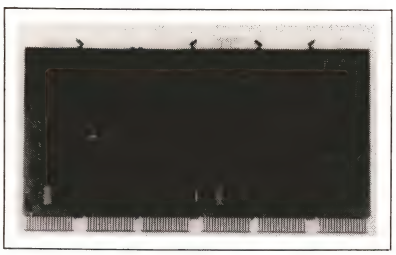


New Products

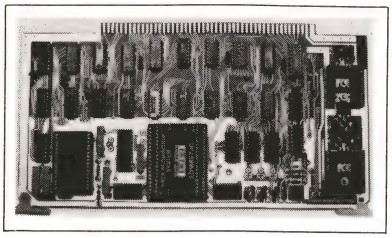


MICRO-CONTROLLER CARD. This board allows designers to rapidly incorporate an 8085 µP into control systems as an economic replacement for logic designs. In its simplest form, the 4×5-in. unit need only contain the CPU and one EPROM, but it can provide up to 76 I/O lines (with EIAA Standard serial interface), 8×4k of program memory and 8×4.6k of RAM. $195 (100). **FH&M Enterprises Inc,** 1850 Gravers Rd, Norristown, PA 19401. Phone (215) 277-8487. **Circle No 328**

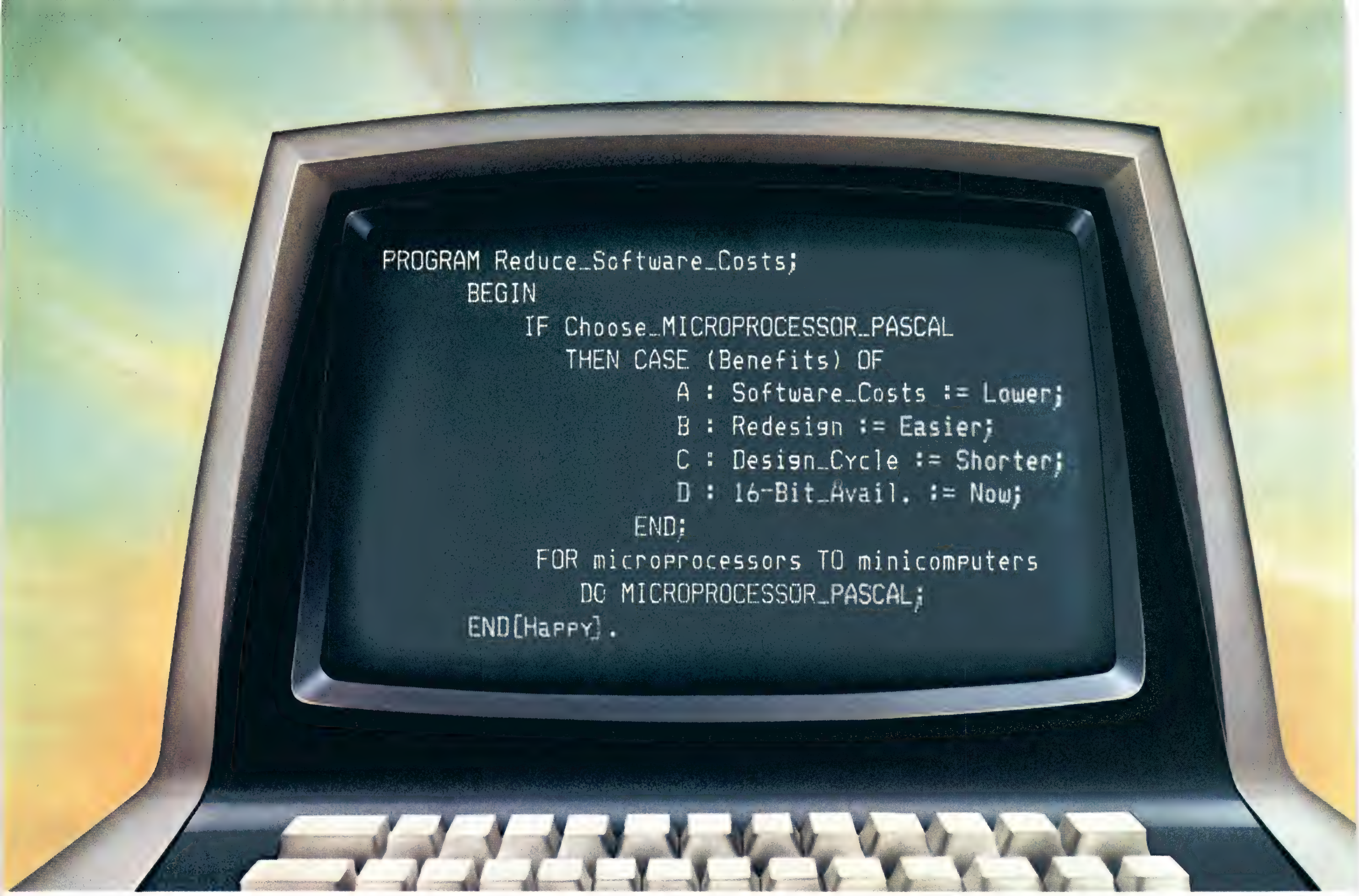
APL CONTROLLER OPTION. Upgrading the 30-cps LA36 DECwriter teleprinter to 165 cps, this APL option adds on to its manufacturer's DS120 terminal controller. The option stores the APL character set in ROM and allows you to print either APL or standard ASCII characters. The unit can generate printed characters while simultaneously underlining them, increasing throughput. APL package, $125; DS120, $750. **Datasouth Computer Corp,** 627-F Minuet Lane, Charlotte, NC 28210. Phone (704) 523-8500. **Circle No 329**



MODEM INTERFACE. Adapting its manufacturer's communication MUXs to Bell 103- and 202-type modems, the DM/16 provides dataset control for 16 channels on one hex-sized board. This unit features on-board switches for address and vector selection and four 40-pin Berg connectors that permit links to an EIA distribution panel. The board meets EIA/CCITT electrical specifications. $1400. **Able Computer,** 1751 Langley Ave, Irvine, CA. Phone (714) 979-7030. **Circle No 330**



12-BIT A/D CONVERTER. Compatible with the S-100 bus, this board adds 16 single-ended or 8 differential channels to Z80 and 8080 µP systems. The board operates in four modes: status test, CPU suspension, 8080 priority interrupt and three Z80 interrupt conditions. Options include an instrumentation amplifier, a programmable-gain amplifier and a high-accuracy converter. $575. **California Data Corp,** 3475 Old Conejo Rd, Suite C-10, Newbury Park, CA 91320. Phone (805) 498-3651. **Circle No 331**



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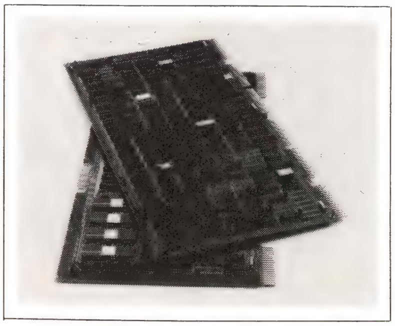
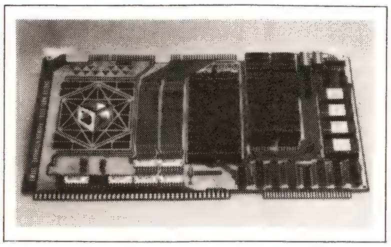
New Products



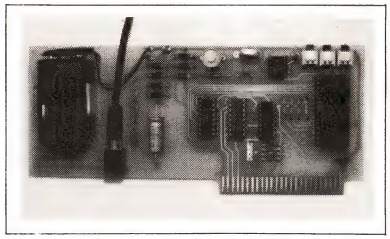
DISC CONTROLLER. Model 3211 interfaces any PDP-11 series computer to as many as four SMD-type drives in any capacity mix. This controller handles data rates from 806k to 1.2M bytes/sec. Mountable on a quad-system backplane, the unit provides direct access to all read/write block transfers by utilizing the Unibus' nonprocessor request facility. $6100. **Ball Computer Products,** 860 E Arques Ave, Sunnyvale, CA 94086. Phone (408) 733-6700. **Circle No 332**

MEMORY INTERFACE. The EM-115 interfaces 86-pin Multibus connectors to two 50-conductor ribbon cables, which in



turn interface to this manufacturer's dual-port memory subsystem. The board also provides optional termination resistors for the bus and up to 16k of expansion memory. $650, fully populated; $195, unpopulated. **Datacube SMK Inc,** Box 405, Reading, MA 01867. Phone (617) 944-4600. **Circle No 333**

64k MEMORY BOARDS. Both of these Multibus-compatible boards feature 250-nsec access times, page-switching options, on-board refresh and sequential refresh. The RMEM-64/8+16BS Mega Memory byte-swap board suits both 8- and 16-bit bus masters and offers 1M-byte or ½M-word addressability. The RMEM-64/8+16 Mega Memory board provides up to 1M byte in Byte mode or 1M word in Word mode. $1600 for the 8+16BS; $1700 for the 8+16. **Relational Memory Systems Inc,** 1180 Miraloma Way, Sunnyvale, CA 94086. Phone (408) 732-5520. **Circle No 334**

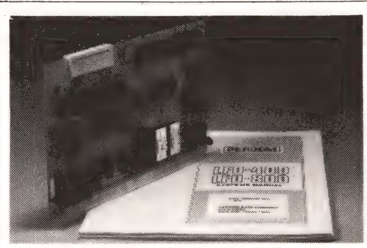


REAL-TIME CLOCK. Compatible with Apple II computers, the APT-1 produces 6-digit time information for CRT displays and printouts or for tasks such as timing events, controlling peripherals and data logging. The clock package includes an external wall transformer that keeps the clock running when the computer is off. The board contains an ac/crystal timebase and can provide 12- or 24-hour readings in either BCD or ASCII formats. $80. **Westside Electronics,** Box 636, Chatsworth, CA 91311. **Circle No 461**

New Products

CASSETTE INTERFACE. Accepting 110- or 300-baud inputs from TTL, CMOS, RS-232, TTY (switch closure) or frequency-shift-keyed (byte standard) sources, this interface board handles outputs to TTL, CMOS, RS-232, TTY (current loop) or audio-recorder (byte standard) devices. The 2¼×4½-in. card also furnishes timing marks for communications sources. $142. **Electronic Product Associates Inc,** 1157 Vega St, San Diego, CA 92110. Phone (714) 276-8911. **Circle No 462**

CARD-CAGE PACKAGE. The PC 80 package includes a 9-slot Multibus card cage and power supply contained in a 19-in. rack-mount chassis. The power supply delivers +5V at 30A, −5V at 1A, +12V at 4A and −12V at 1.7A; the unit also provides four switched ac outlets, provision for battery backup, a switched contact closure for remote dc, power-fail sequencing and a line time clock. $1195. **Comark Corp,** 257 Crescent St, Waltham, MA 02154. Phone (617) 894-7000. **Circle No 463**



CONVERSION PACKAGE. This conversion provision allows you to use its manufacturer's disc software on Southwest Technical Products and Smoke Signal Broadcasting minidisc systems. It includes a controller/interface card, two disc operating systems in EPROM (MINIDOS and MINIDOS-PLUSX), Super BASIC, a cable connector (for SWTP's disc cable) and full instructions and user manuals. $250. **Percom Data Co,** 211 N Kirby, Garland, TX 75042. Phone (214) 272-3421. **Circle No 464**

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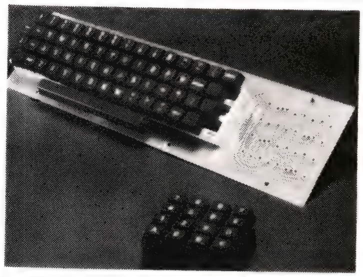
For more information, Circle No 166

New Products

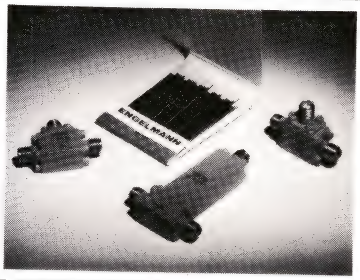
COMPONENTS & PACKAGING



KEYBOARDS. Because of their crossbar contact design, Sabrecoil keyboards incorporate only three parts for each switch position. The 1-piece frame that houses all switch parts provides ease of mounting and deflection resistance for the entire assembly.

Offered in either a 16-key (4×4) configuration or a 60-position alphanumeric array, the units can be provided with or without keytops or a custom pc board. They come in stepped or sloped configurations; the doubleshot molded keytops have wide faces and clean legends.

Contact noise is minimal; life expectancy exceeds 10^6 cycles per position. Plunger travel equals 3.4 mm, with an overtravel of approximately 1.5 mm beyond contact make-point. Operating force specs at 60g. $10.80 (5000) for a 54-key unit with keytops and spacebar but without pc board. **Mechanical Enterprises Inc,** 8000 Forbes Pl, Springfield, VA 22151. Phone (703) 321-8282. **Circle No 255**



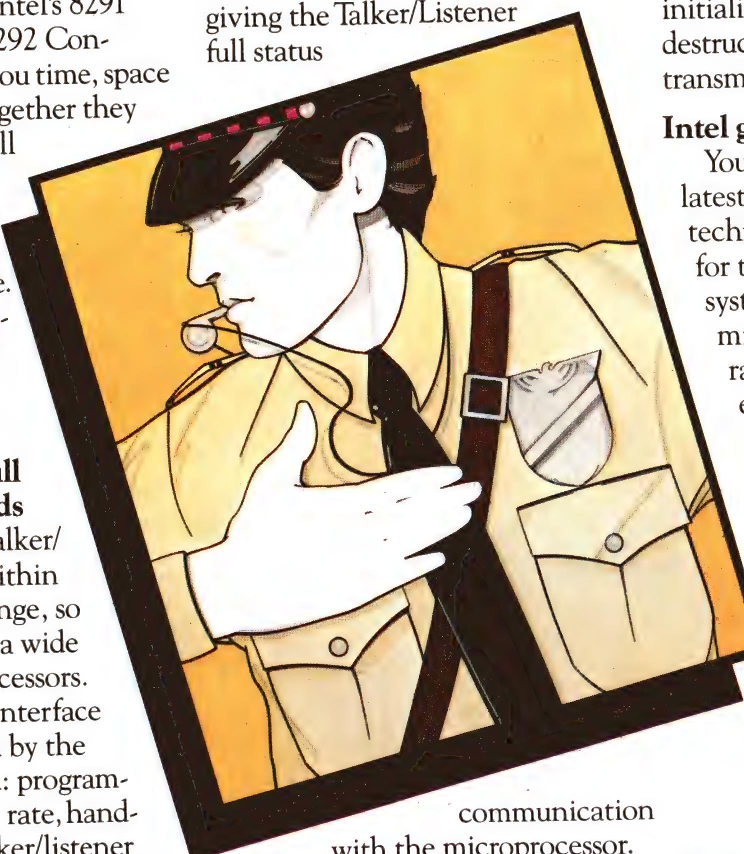
DIVIDER. Housed in a 1.6×0.5×0.375-in. package, Model D301M strip-line power divider covers a range of 1 to 18 GHz. Over the entire range, minimum guaranteed specs include: 1.5 to 1.7 input VSWR, 1.3 to 1.6 output VSWR, 0.4- to 0.9-dB loss, 12- to 20-dB isolation, 0.2- to 0.4-dB balance and 1 to 4° phase. $95. **Engelmann Microwave Co,** Skyline Dr, Montville, NJ 07045. Phone (201) 334-5700. **Circle No 256**

Traffic Control for GPIB

Intel's new Talker/Listener and Controller give you the green light for simplified IEEE-488 systems.

Microprocessors are revolutionizing the instrumentation marketplace. Thanks to GPIB, systems manufacturers have the first standard interface that allows intelligent instruments to communicate with each other. Now the leading supplier of microprocessors delivers two peripheral chips—a Talker/Listener and a Controller—that make it even easier to get on the IEEE-488 bus.

Instead of building your own interface logic, use Intel's 8291 Talker/Listener or 8292 Controller. They'll save you time, space and money. Used together they let you implement all the IEEE-488 Standard bus functions without additional hardware or software. There's no more efficient traffic control for microprocessor-based systems.



Implement the full interface standards

Our 16-register Talker/Listener operates within a 1-8 MHz clock range, so you can use it with a wide variety of microprocessors. It performs all the interface functions described by the IEEE-488 Standard: programmable data transfer rate, handshake protocol, talker/listener addressing procedures, device clearing and triggering and both serial and parallel polling schemes. But the 8291 gives you even more control.

For flexibility beyond the call of duty, Intel's Talker/Listener has three addressing modes. According to your application, you can address 8291 as either a major or minor talker/listener with either primary or secondary addressing.

Selectable interrupts and EOS

8291 lets you initialize interrupt conditions, too. Any of 12 interrupt status bits can be enabled, giving the Talker/Listener full status communication with the microprocessor.

Finally, the 8291 is the only LSI device to offer EOS (end of sequence) message recognition. Working with a GPIB controller device, this EOS capability means added control in handling multi-byte transfers.

First GPIB controller-on-a-chip

Now the GPIB control function is in LSI form, too. Our 8292 Controller communicates with the Talker/Listeners in your system to complete implementation of the IEEE-488 Standard, including transfer control protocol. It also executes service routines as indicated by interrupts and allows for seizure of control and/or initialization of the bus without destruction of ongoing data transmission.

Intel gives you the go ahead

You can depend on Intel for the latest advances in microcomputer technology. Everything you need for tomorrow's instrumentation systems is here today, from microcomputers to the broadest range of memory and peripheral components available.

Now you can build with Intel's new IEEE-488 Talker/Listener and Controller chips. For detailed information, contact your local Intel sales office or write: Intel Corporation, 3065 Bowers Avenue, Santa Clara, CA 95051.

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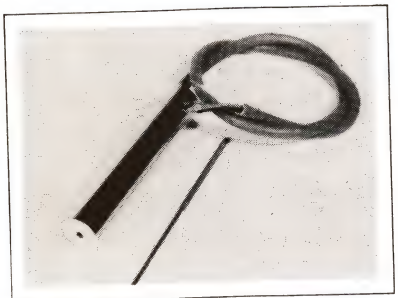
Circle no. 169 for information

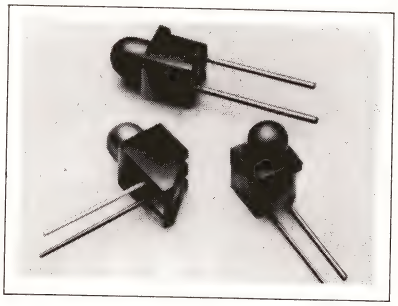
New Products



DC/DC LVDTs. These linear variable-differential transducers measure a variety of physical functions that can be translated into linear displacements. They maintain all the desirable characteristics of ac/ac units while offering the simplicity of dc/dc operation. The devices consist of two integral parts: an ac-in/ac-out LVDT and a carrier-signal-conditioning module. You can specify displacement capability ranging from ±0.05 to ±2 in. The units operate from simple power sources—including dry cells. $278.30 to $532.40. **Transducer Systems Inc,** 710 Davisville Rd, Willow Grove, PA 19090. Phone (215) 657-0800. **Circle No 257**

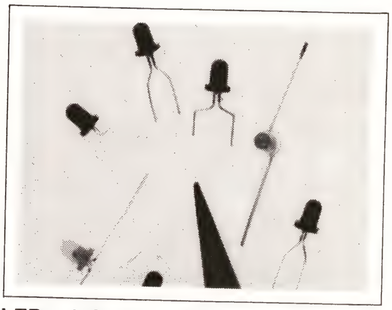
DIODE SOCKETS. Series 6091 units provide for Kelvin contact and accept most axial-lead components for burn-in and test. Double-ended designs accommodate component lengths up to 1.815 in.; single-ended units handle any component size. Low-insertion-force contacts are available in beryllium copper or beryllium nickel, and standard plating is 30 μin. gold over 100 μin. of nickel. The one-piece-body construction gives dependable performance under conditions of excessive vibration and pressure. **Wells Electronics Inc,** 1701 S Main St, South Bend, IN 46623. Phone (219) 287-5941. **Circle No 258**

RELAYS. Model 268 plug-ins come in spdt and dpdt configurations. Their silver or cadmium-oxide stationary contacts and fine-silver movable contacts are rated for 15A or ½ hp at 120V ac and 15A or 1 hp at 240V dc. Coil-voltage ratings range from 6 to 240V ac and 6 to 110V dc, and coil resistance equals 16 kΩ max. Quick-connect/solder-type terminals are standard; pc or barrier types, optional. Operating ranges are −45 to +60°C and −45 to +75°C for ac and dc types, respectively. **Deltrol Controls,** 2745 S 19th St, Milwaukee, WI 53215. Phone (414) 671-6800. **Circle No 259**



LEDs. Series 550 logic-state/fault indicators have a maximum current rating of 30 mA and come in red, green and yellow. Their high luminous intensities—4 mcd typ at 10 mA—also suit them for backpanel illumination. These LEDs feature a wide viewing angle, polarity identification, lifetimes measured in years and a black case that enhances contrast ratio. Designed for high-density packaging, they are vibration and shock resistant. $0.58 (1000). **Dialight,** 203 Harrison Pl, Brooklyn, NY 11237. Phone (212) 497-7600.
Circle No 260

TCXOs. CO-255 Series units offer stability to $\pm 2\times10^{-7}$ over the 0 to 50°C range or $\pm 1\times10^{-6}$ over -55 to $+85$°C. Frequencies range to 400 MHz with long-term stability better than 1×10^{-8}/day or 2×10^{-6}/yr. The oscillators work with supply voltages in the 12 to 28V range and provide an output of 7 dBm into 50Ω (13 dBm optional). Lower frequency models are available with CMOS or TTL compatible outputs. From $225 (10). Delivery, 10 to 16 wks ARO. **Vectron Laboratories Inc,** 166 Glover Ave, Norwalk, CT 06850. Phone (203) 853-4433. **Circle No 261**

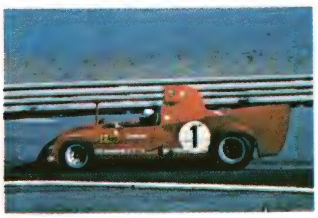


LEDs. MSL Series formed-leaded T-¾ red and yellow lamps have typical luminous intensities ranging from 4 to 12 mcd (at 25-mA forward current) and viewing angles of 18 to 30°. They can be supplied either as illuminators or indicators: Illuminators come with a transparent tinted lens, while indicators have a diffused tinted lens for maximum contrast and off-axis visibility in high-ambient-light applications. $0.53 to $0.69. **Opcoa,** 330 Talmadge Rd, Edison, NJ 08817. Phone (201) 287-0355. **Circle No 262**

COUNTER. A 5-digit (0.5-in. LED) universal counter, Model RC-5 performs any of five internally selectable functions: event counting, frequency, time interval, period and frequency ratio. Hold and reset lines are accessed via terminal-block connections, and time-base settings of 0.01, 0.1, 1 and 10 sec can be internally jumper selected. The RC-5 has a dc to 1-MHz frequency range and accepts input voltages of 3 to 15V peak. $144. **Non-Linear Systems Inc,** Box N, Del Mar, CA 92014. Phone (714) 755-1134. **Circle No 263**

Pinpoint Noise and Vibration 4 Hours Sooner

with Nicolet's Dual-Channel FFT Analyzer



On-site location and evaluation of each source of noise or vibration is made quickly and easily with the 660A. Its world-wide use includes Navy Surface Effect Ships, John Deere tractors (shown in special anechoic chamber), and Alfa Romeo's ... wherever noise source evaluation and structural integrity are vital.

660A shown with Dual-Disk Mass Storage Add-on

The Nicolet 660A Dual-Channel FFT Analyzer has been specifically designed to get good data faster and more reliably in the field as well as the lab with the minimum of electronic instrument experience and **no** computer programming knowledge.

½ hr. saved in setup ...

The Nicolet 660A is a single, portable unit ... you just plug-in and start analyzing instantly ... no interconnections ... no program load (and reload) ... stored control setups instantly recalled to duplicate past tests exactly.

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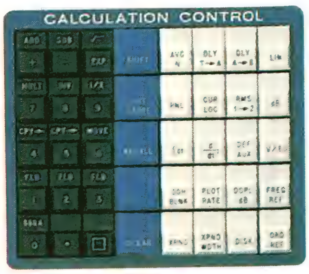
The 660A's simple self-explanatory controls not only allow a new user to get good data almost immediately, but the occasional user does not have to spend hours with the manual each time he runs a test.



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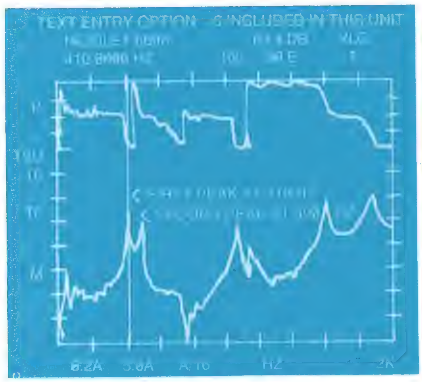
Days saved by understanding results ...

Meaningful data eliminates test **reruns** ... plots and disk-stored data completely annotated, including operator-entered identifying text (opt.) ... data with low coherence blanked ... automatic transducer equalization ... engineering-unit calibration.



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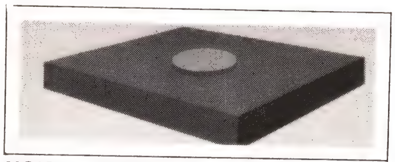
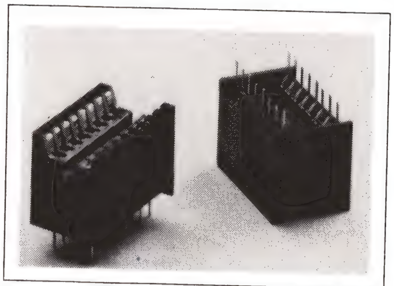
New Products

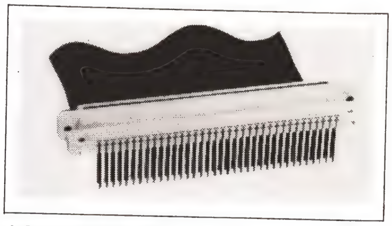


NOISE DIODE. Covering a 10-GHz range, the NDC-101 noise-diode chip features a noise output in excess of 32 dB with a maximum variation of 2 dB/GHz. It operates over −55 to +85°C and has voltage and current specs of 28V and 10 mA, respectively. Measuring 0.02×0.02×0.005 in., the chip provides a gold contact for the anode and gold backing for the cathode. $27. Delivery, 4 wks ARO. **Micronetics Inc,** 36 Oak St, Norwood, NJ 07648. Phone (201) 767-1320. **Circle No 264**

BRIDGES. Despite their size (0.42×0.62 ×0.18 in.), Series SDA 247 and 248 full-wave, single-phase bridge assemblies have peak inverse-voltage ratings ranging to 4 kV. The low-voltage 248 units have an output-current capability of 2A (50 to 1000V PIV); 247 units handle 0.5A current (1500 to 4000V PIV). Peak recurrent and one-cycle surge-current ratings are 10 and 50A for 248 units and 2.5 and 10A for 247 devices. SDA 248, $12 to $45 (100); SDA 247, $3.25 to $6. **Solid State Devices Inc,** 14830 Valley View Ave, La Mirada, CA 90638. Phone (213) 921-9660. **Circle No 265**



IC SOCKETS. Series 3910 devices are designed especially for high-density burn-in applications. They feature an easy-entry lead-in ramp and a thin-wall construction that allows considerable savings in board space. The units' large double-beam contacts are gold plated and self-aligning. Contact specs include current rating of 1A, 5000-insertion lifetime and resistance of 15 mΩ max at 1A. **Stanford Applied Engineering Inc,** 340 Martin Ave, Santa Clara, CA 95050. Phone (408) 243-9200. **Circle No 266**



CONNECTORS. This family of right-angle-plug to flat-ribbon-cable connectors is designed for mass termination of multiconductor cables. Wire-wrappable and solder-style plugs are offered. The right-angle plugs have a dual-fingered readout for mating with up to 72-position connector receptacles. The dual-readout receptacles feature bifurcated gold-plated beryllium contacts. Insulation-piercing contacts are on 0.5-in. centers. $14.20 for a mated pair. **Mupac Corp,** 646 Summer St, Brockton, MA 02402. Phone (617) 588-6110. **Circle No 267**

Unitrode gives you the choice you need in industrial NPN silicon power transistors. Even if what you need is beyond the ordinary.

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For more information, Circle No 47

New Products

DPM. Utilizing 0.3-in.-high LED readouts, the 4½-digit Model PM-450 comes with full-scale-range options of 1.999, 19.999, 199.99 and 1000V dc. It weighs less than 4 oz and provides such features as 0.1-mV resolution, 0.02% accuracy, autopolarity and overload protection, autozeroing, 80-dB CMR, input-voltage protection and programmable decimal points. The meter operates on 5V dc; a 115V-ac supply is optional. $114. **Non-Linear Systems Inc,** Box N, Del Mar, CA 92014. Phone (714) 755-1134. **Circle No 268**

ATTENUATORS. Offered in both 50Ω (Model 8123) and 75Ω (8133) versions, these rotary attenuators span a 0 to 1-dB range in 0.1-dB steps. Employing thick-film resistive networks, the devices feature an accuracy of ±0.02 dB over a frequency range of dc to 500 MHz. Model 8123 comes with SMA or BNC jack connectors; 8133 devices are furnished with F, BNC or SMC connectors. Other connectors are available for both units on special order. Model 8123, $145; 8133, $195. **Telonic Berkeley,** 2825 Laguna Canyon Rd, Laguna Beach, CA 92652. Phone (714) 494-9401. **Circle No 269**

SWITCHES. This line of Rockette switches features mechanically displayed color-coded strips or legends that appear through windows in the rocker button to provide positive indication of switch position. You can specify single- and double-pole circuits, rated from 6 to 20A at 125V ac. Units come in two rocker styles (serrated and smooth), three colors (red, white, black), a variety of mounting styles (subpanel, flush and snap-in) and with one or two windows. $0.50 to $5.51, depending on qty. Delivery, 14 to 16 wks ARO. **Cutler-Hammer Inc,** 4201 N 27th St, Milwaukee, WI 53216. Phone (414) 442-7800. **Circle No 270**

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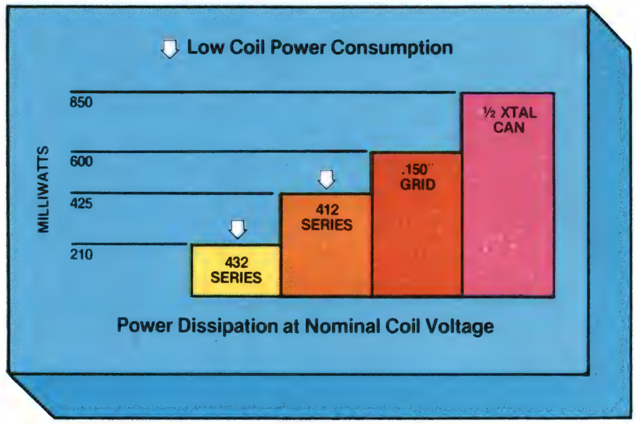
TO-5 RELAY UPDATE

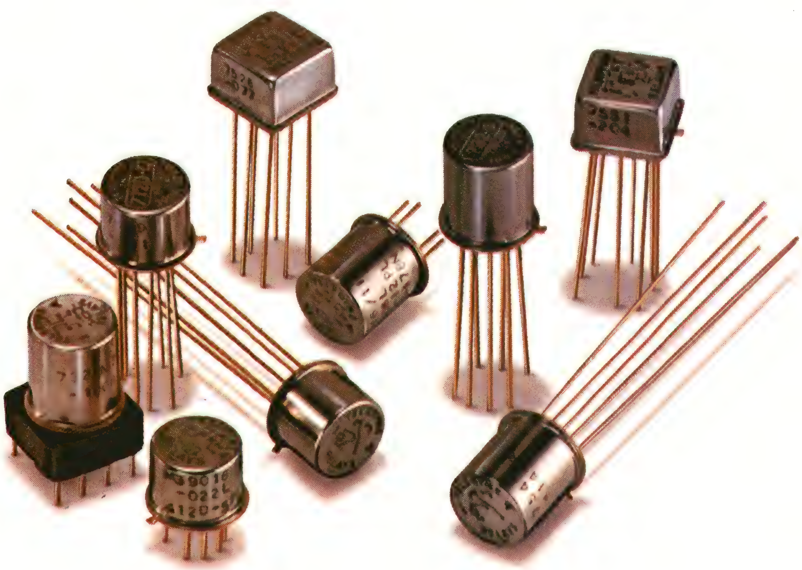
Solve your energy crisis with TO-5 relays



Subminiaturization and pc board compatibility — two obvious advantages of Teledyne TO-5 relays. But there's another outstanding advantage: low coil power consumption. This feature is best illustrated in the above graph which shows our TO-5 relay power savings compared to other miniature relays. The Teledyne 412 Series dissipates about 30% less power than the .150″ grid relay, and 50% less than the ½ crystal can. Our sensitive 432 Series is 65% less than the .150″ grid. And 75% less than the ½ crystal can.

This means you can save over 6 watts in a typical system using, let's say, ten TO-5 relays. In the end, you gain significant advantages in terms of thermal and power supply considerations that can help prevent an "energy crisis" in your system.

Our complete line of TO-5 relays includes military and commercial/industrial types, with virtually all military versions qualified to established reliability MIL specs. For complete data, contact Teledyne Relays — the people who pioneered the TO-5 relay.



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European Hqtrs.: Abraham Lincoln Strasse 38-42 • 62 Wiesbaden, W. Germany • 6121-700811

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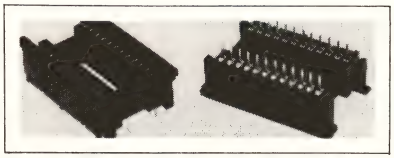
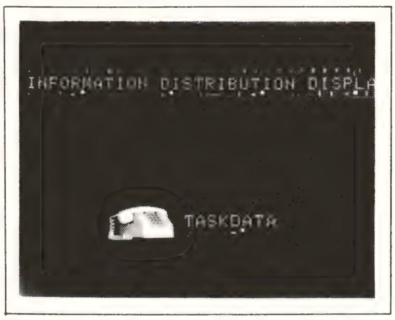
New Products



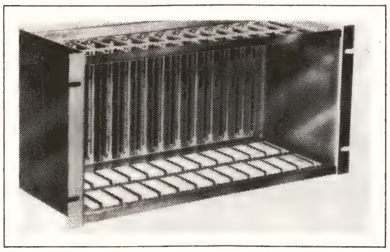
ZIF SOCKETS. These 24-pin IC sockets employ actuating bars on each side to open and close their contacts. Edge-wipe contact design provides high contact retention, and tapered entry ramps condition and guide IC leads into the sockets' semiclosed contact-entry area. After conditioning, contact resistance is 14 mΩ, and withdrawal force equals 30g. The units' CA770 contacts are offered unplated (11979-24-02) or gold plated (11979-24-01). **Scanbe Div Zero Corp,** 3445 Fletcher Ave, El Monte, CA 91731. Phone (213) 579-2300. **Circle No 271**

MIXERS. With a LO power level of +23 dBm, SAY and ZFY double-balanced mixers have a 1-dB conversion-compression point at +20-dBm RF input; 2-tone 3rd-order IM is 70 dB below the desired IF. The models cover a 100 kHz to 2.4 GHz bandwidth. Other features include 45-dB isolation and 5.5- to 7.3-dB typical conversion loss. SAY devices are intended for pc-board mounting; ZFY units come with coaxial connectors. $54.95 to $84.95. **Mini-Circuits Laboratory,** 2625 E 14th St, Brooklyn, NY 11235. Phone (212) 769-0200. **Circle No 272**

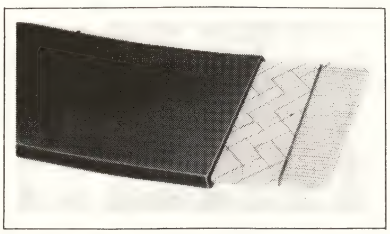


DISPLAY. With a digit height of 1.75 in., the Model 4450 Taskdata 8-character alphanumeric display is readable from up to 90 ft away. The display's 32-character memory is divided into 4 sectors of 8 characters; upon command, the panel can display an individual sector or 2, 3 or 4 in sequence. The pc board contains all support electronics and requires a single 5V supply. Housing and power supply are available. $182 (100). **Logic Electric,** Box 5154, Kingwood, TX 77339. Phone (713) 446-1021. **Circle No 273**

RELAYS. Leak-free, N_2-gas-filled and plastic-sealed, HBE relays can be submerged in any solvent for automatic cleaning. Available in 1C and 2C configurations, they have low operating-power requirements (230 to 370 mW), contact ratings of 0.5A at 125V ac and 2A at 30V dc, and control-voltage ratings of 3 to 48V dc. The devices measure 0.787×0.61×0.433 in. and have a terminal footprint that matches 16-pin IC sockets. $1.49 (1000). Delivery, stock to 90 days ARO. **Aromat Corp,** 250 Sheffield St, Mountainside, NJ 07092. Phone (201) 232-4260. **Circle No 274**

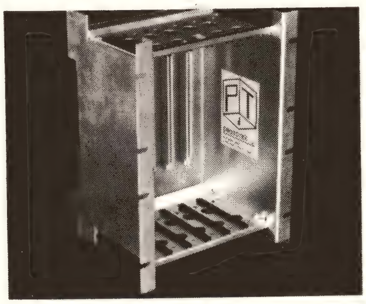


CARD RACK. Designed for mounting in standard 19-in. cabinets, the 13WR125 can hold a backpanel equipped with 13 122-pin card-edge connectors. Heavy irridited aluminum bars serve to mount user-supplied backpanels from a variety of manufacturers. The rack's card guides, spaced on 1.2-in. centers, are formed into plated-steel top and bottom plates to accept ⅛-in.-thick, 7.375×7-in. pluggable wrap-pin IC panels. $59.95. **Unitrack,** 8738 West Chester Pike, Upper Darby, PA 19082. Phone (215) 789-3820. **Circle No 275**



SHIELDED CABLE. Offered in 100-ft rolls with 9 to 64 conductors, Series 177 jacketed cable is designed primarily for use with D, ribbon and male connectors. UL listed, it features a 28-AWG stranded PVC-insulated wire with a flexible aluminum-foil shielding surrounded by a black PVC outer jacket. An integral drain wire can be terminated directly in the connector or pigtailed out to provide a shielded ground termination. $0.35 to $0.65/ft. **T&B/Ansley Corp,** 3208 Humboldt St, Los Angeles, CA 90031. Phone (213) 223-2331. **Circle No 276**

New Products



PROTOTYPE SYSTEM. The CWA-105P kit includes card-cage metal work, a pc backplane, a 5V regulator, five dual 50-position card-edge connectors, 10 plastic card guides, pullup resistors and assorted hardware. You can gang two of the 9.5-in. card cages to fit standard 19-in. racks; each card cage features packing densities of 11 cards on 0.6-in. centers or five cards on 1.2-in. centers. A wire-wrappable-type backplane is also available, and the system has provisions for terminating all bused signals. $155. **Prototek Inc,** Box 46512, Cincinnati, OH 45246. Phone (513) 874-5094.
Circle No 277

CONNECTORS. These male connectors feature a box shape with a single polarization slot that assures compatibility with female socket-transition connectors and provides protection for mating pins. They come with or without mounting ears and with 10 to 60 mating pins. Both versions feature a 1-piece design and insulation-displacement contacts. An optional strain relief is available for the units without mounting ears. $0.093 per contact (OEM qty). **T&B/Ansley Corp,** 3208 Humboldt St, Los Angeles, CA 90031. Phone (213) 223-2331. **Circle No 278**

COUNTER. Not much bigger than a pack of cigarettes, Model 094 binary counter counts to 4095 events and displays the total on LEDs. The unit offers fast (1 μsec) and slow (100 msec) response times and can be set to trigger on either the rising or falling edge of the signal. Model 094 operates on an external 5- to 15V-dc power source and can be linked directly to a second unit to extend the counting range. $41.95. **Cincinnati Electrosystems Inc,** 469 Ward's Corner Rd, Loveland, OH 45140. Phone (513) 831-4347. **Circle No 279**

DISPLAY. Model PM 512-60 flat-panel plasma alphanumeric/graphics display has a 512×512-line (60 lines/in.) dot-matrix display area. The panel's more than 260,000 display points can be randomly addressed and selectively erased. The panel has inherent memory, a constant 9-mil spot size, 30:1 contrast ratio and 160° viewing angle. Lifetime is spec'd at 20,000 hrs. $1250 (100). **Interstate Electronics Corp,** Box 3117, Anaheim, CA 92803. Phone (714) 772-2811. **Circle No 280**

FLAT-CABLE CONNECTORS. These socket connectors (Series IDS) and pc-board headers (Series IDH) are designed to reduce assembly time. IDS units come with lid and body preassembled; an optional strain-relief bar ensures reliable cable connection. IDH devices accommodate straight or right-angle mounting with either solder or wrap-pin terminations. An ejector/latch feature keeps the headers in place when latched and serves as a handy socket ejector when opened. **Robinson-Nugent Inc,** 800 E Eighth St, New Albany, IN 47150. Phone (812) 945-0211. **Circle No 281**

See page 79

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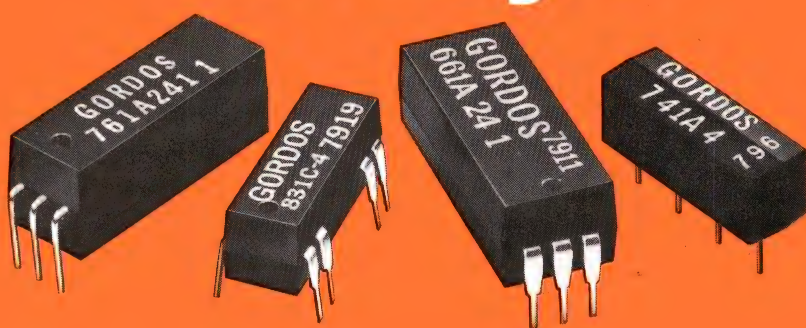

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Release time (mSec)	.05	.05	.5	1.0 (N/O)
Contact rating (watts)	10	50	10	3
Maximum initial contact resistance (ohms)	.200	1.0	.200	.200
Maximum switching (VDC)	200	200	200	28
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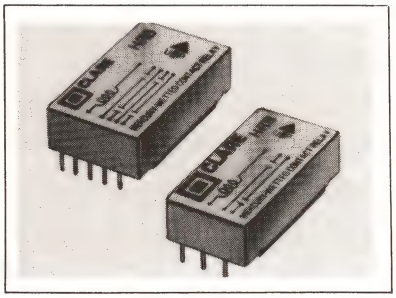
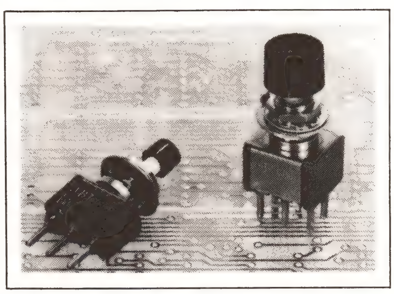
For more information, Circle No 193

New Products



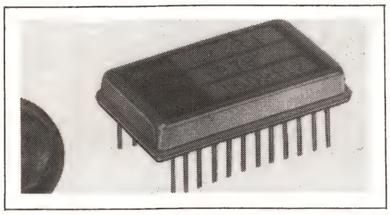
RELAYS. HR Series mercury relays feature a minimum of 20-billion operations. They handle low-level to 50-VA currents; alternately switching between low and high loads does not affect performance or life. Two grid patterns are available: 1×1 in. in 1 through 6 Form A and 1×1.5 in. in 1 through 5 Form A. Standoff voltage is spec'd at 1000V ac. Operate time is 3 msec max and release time (with suppression) is 2 msec max. $3.80 to $16 (1000). **C P Clare & Co,** 3101 W Pratt Ave, Chicago, IL 60645. Phone (312) 262-7700. **Circle No 282**

PHASE DETECTORS. Series 4749XH balanced detectors serve phase-bridge or phase-modulated system-receiver applications. Designed to compare two millimeter-wave signals, they come in five waveguide bands spanning 18 to 110 GHz. Each device consists of a matched pair of Schottky-barrier diodes in reduced-height waveguide cavities, plus a folded hybrid tee. The detectors provide good isolation between RF ports, low dc offset and good noise-cancellation characteristics. $3000. Delivery, 90 days ARO. **Hughes Electron Dynamics Div,** 3100 W Lomita Blvd, Torrance, CA 90509. Phone (213) 670-1515. **Circle No 283**



PUSHBUTTON SWITCHES. This line of momentary snap-action switches feature gold-on-nickel contacts and nonteasable operation. Both spdt and dpdt styles are offered. Contacts are rated for 1A resistive at 125V ac or 28V dc, 0.4 VA at 28V ac/dc. Standard cap colors are red, white or black. Terminals are epoxy-sealed solder lug or pc-mount type. $0.97 to $5.18. **Cutler-Hammer,** 4201 N 27th St, Milwaukee, WI 53216. Phone (414) 442-7800. **Circle No 284**

SWITCHES. Indexer bidirectional push-button front-mount switches measure only 7.95 mm wide. They are designed to switch logic-level circuits of not more than 50 mA at 28V dc or ac and have a life expectancy of 10^6 detent operations. The 10-position switches come in matte black and accommodate all popular codes, including decimal, BCD plus complement and complement only. They are also available with an extended board to accommodate termination pins, stopping and diode suppression circuitry. $3.48 (1000) for BCD code switch. **Inter-Market Inc,** 1946 Lehigh Ave, Glenview, IL 60025. Phone (312) 729-5330. **Circle No 285**



OSCILLATOR. A low-profile, multifrequency crystal-controlled CMOS oscillator, Model L22R simultaneously produces all binary divisions, from 2^0 to 2^{12}, of a fundamental frequency ranging from 8 MHz to 500 Hz. Frequency tolerance specs at ±0.001% from 20 to 40°C and ±0.005% from −40 to +85°C. The oscillator works on 5 to 15V dc with current drain of 1 to 5 mA; it is housed in a 24-pin DIP. Approximately $115. Delivery, 5 wks ARO. **Connor-Winfield Corp,** Box L, West Chicago, IL 60185. Phone (312) 231-5270. **Circle No 286**

PATCH CORD. Model 4648 Maxi-Grabber-to-male-BNC cord comes in lengths of 18, 24, 36, 48 and 60 in. The BNC has a nontarnish finish and PVC insulation that withstands a maximum temperature of 50°C. The Maxi-Grabber is black and red with gold-plated beryllium-copper contacts and glass-filled nylon insulation; it withstands temperatures to 102°C. $7.84. **ITT Pomona Electronics,** 1500 E Ninth St, Pomona, CA 91776. Phone (714) 623-3463. **Circle No 287**

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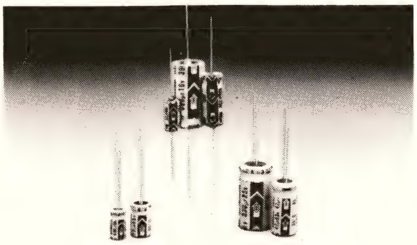

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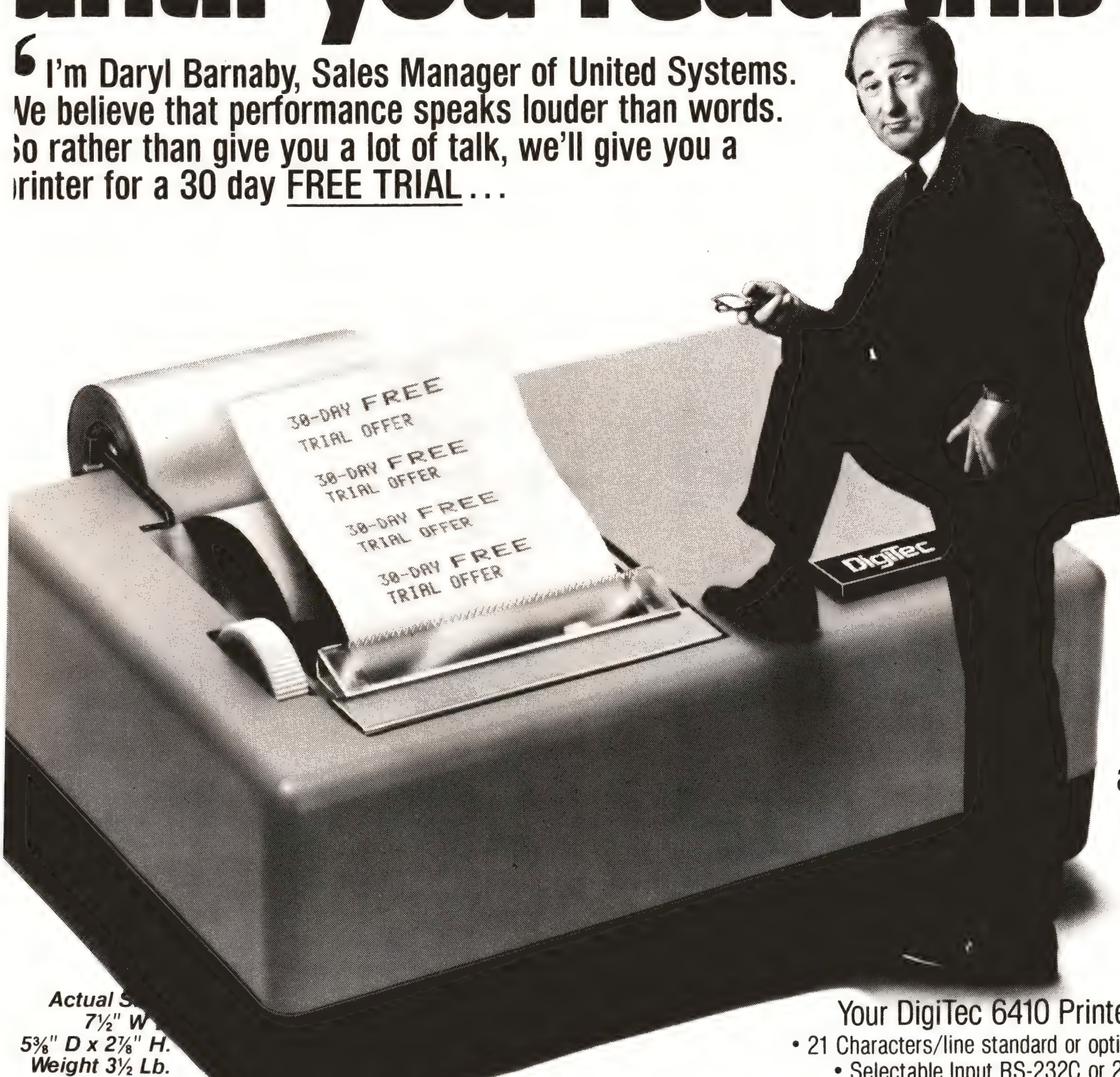

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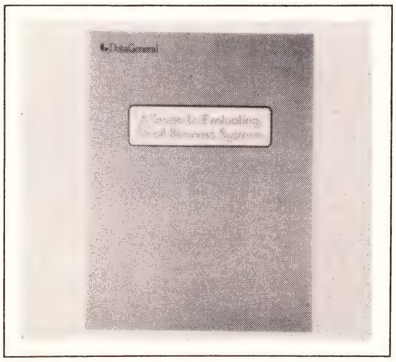

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"A Guide to Evaluating Small Business Systems" uses questions and text to consider factors relevant to the selection of a small-business computer system. The 8-pg Publication No 012-722 describes how to evaluate vendors, software, hardware, the system as a whole and the financial aspects of your purchase. **Data General Corp,** Communications Services, 15 Turnpike Rd, MS 82310, Westboro, MA 01581.

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Application Technique AT-802 illustrates a means of converting a typical digital or analog optical link into a high-precision analog data link by using V/F/V conversion techniques. The 4-pg paper explains how you can obtain accuracy better than ±0.1% (even at dc), as well as a minimum signal bandwidth of 500 kHz. **Dynamic Measurements Corp,** 6 Lowell Ave, Winchester, MA 01890.

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In-depth data on LC filters

Catalog 16F presents a wide range of bandpass, band-reject, linear-phase, high-pass and low-pass LC filters designed for frequencies from 20 Hz to 400 MHz. The 24-pg brochure also contains a filter-facts section, a glossary and specification forms. **Allen Avionics Inc,** 224 E Second St, Mineola, NY 11501.

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Data on an extensive line of miniature, subminiature and microminiature coaxial connectors fills this 208-pg catalog. Full specs, photos, diagrams, application data, selection charts and ordering information help you choose the proper connector. **Omni Spectra,** Microwave Connector Div, 140 Fourth Ave, Waltham, MA 02254.

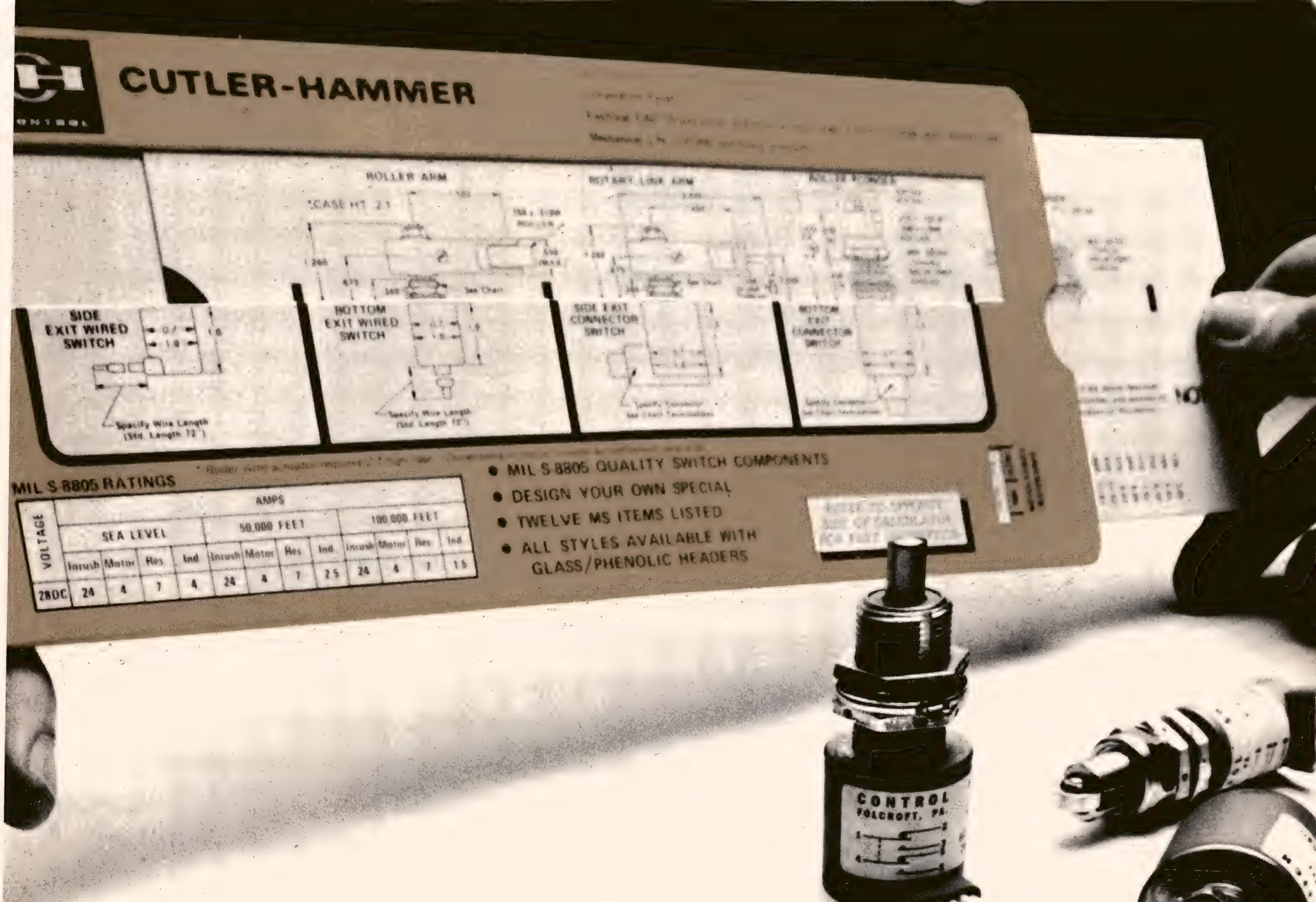
Circle No 466

Pressure-transducer-application considerations

The first six issues of "Pressure Transducer Application Notes" use diagrams, charts and text to discuss such factors as transducer effects, error computation, null adjustment and temperature sensitivity, voltage vs current excitation, pressure-sensitivity self compensation, voltage adjustment, external scaling circuitry, and pressure-switch configuration. **Micro Switch,** 11 W Spring St, Freeport, IL 61032.

Circle No 467

For more information, Circle No 198



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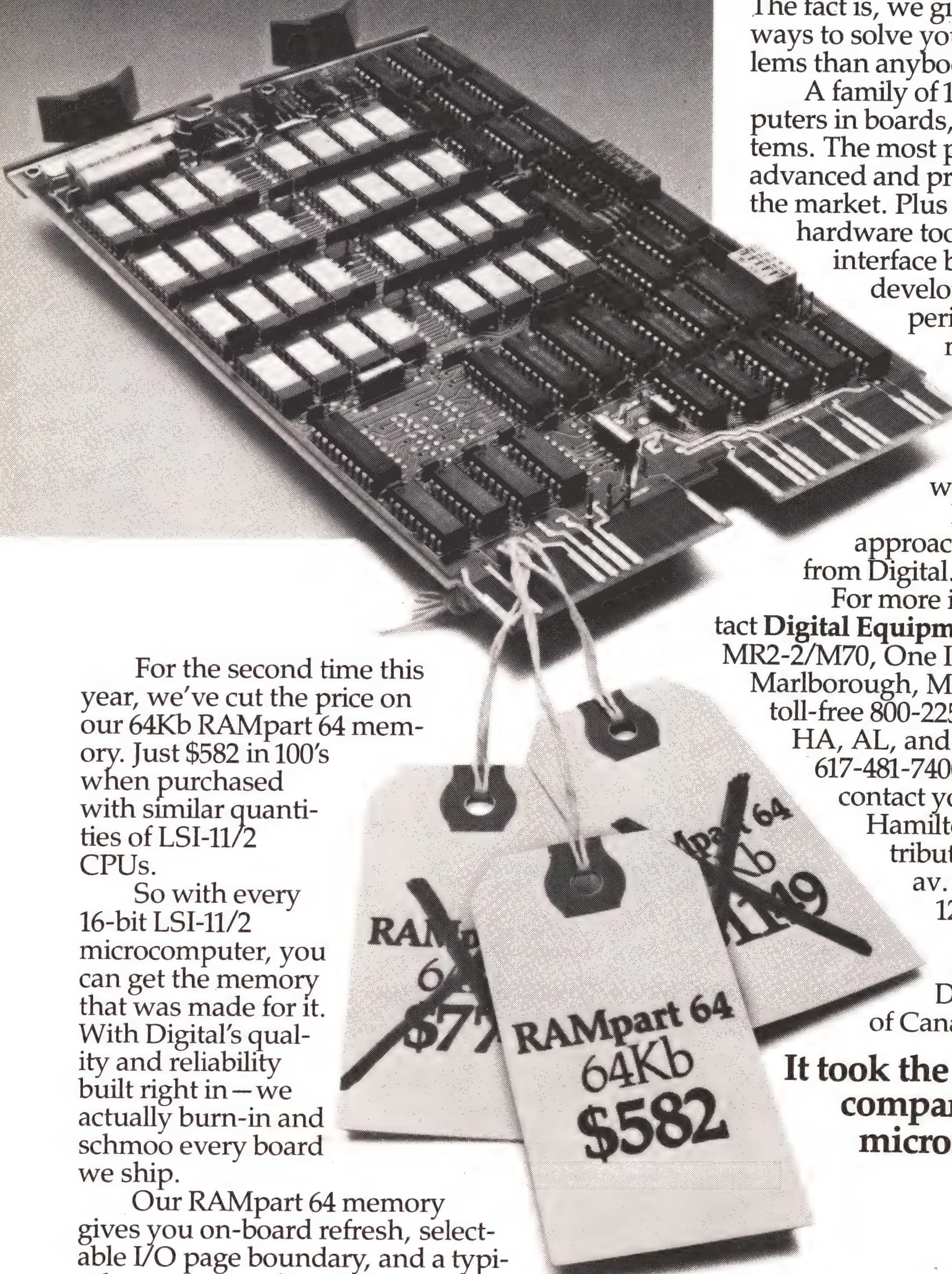

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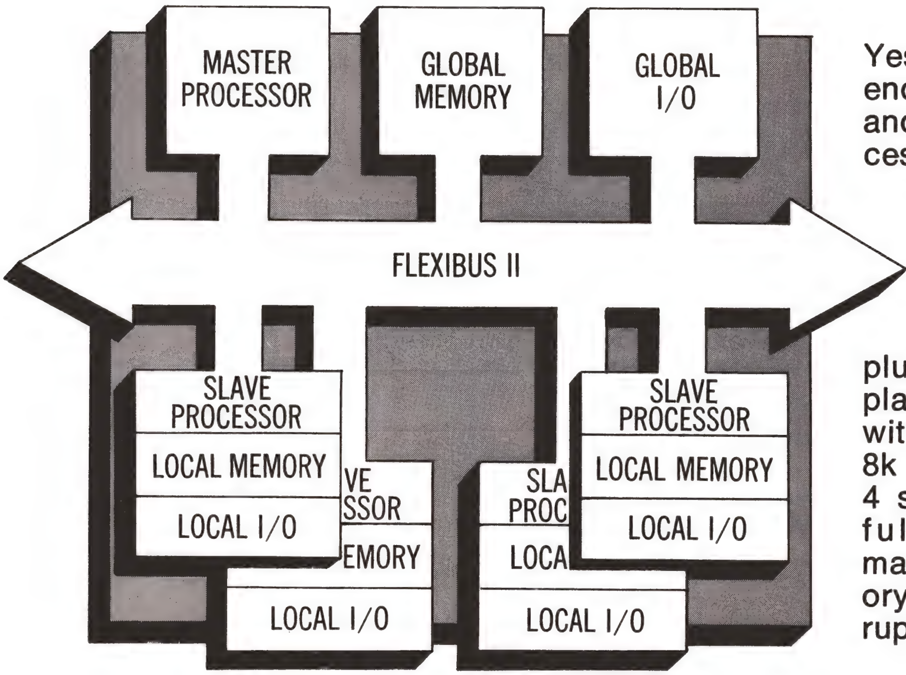
MD, Rob't., Elect. Sales, (301) 766-6374
MI, O-M Sales, (313) 973-9450
MN, Northport Eng., (612) 854-5556
MO, PMA Corp., (314) 569-1220
NJ, ABC Elect., (201) 568-2354
NY, S.F. Foster, (315) 637-5427
S.F. Foster, (716) 265-2072
ABC Elect., (516) 747-6610
ABC Elect., (914) 769-8808
OH, Bear Mktg., (216) 659-3131
PA, Campbell Assoc., (215) 322-6630
TX, Delta Comp., (214) 358-4288
Delta Comp., (713) 783-6848
UT, Parker Webster Co., (801) 487-5911
WI, Sumer, (414) 259-9060
Canada: Ontario, RFQ, Ltd., (416) 626-1445
Quebec, RFQ, Ltd., (514) 694-5724

HITACHI
Hitachi, Ltd. Tokyo, Japan

Stocking Distributors: Bell • Future • Jaco • Marshall • RM Electronics • Time

For more information, Circle No 212

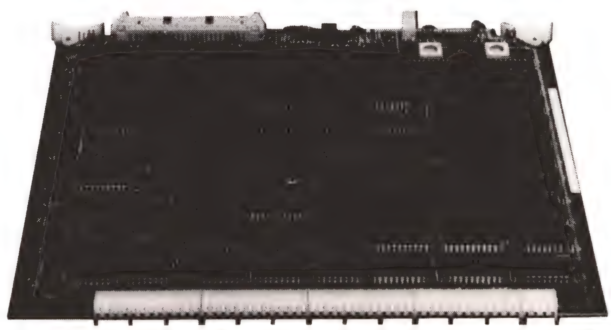
Why buy a Promise when PCS can Deliver the 1861A Slave Computer



Yes, there is a powerful difference between slave computing and multiprocessing. Multiprocessing, in the present context, indicates an ability to perform time-shared tasks on a single processor.

We offer another complete computer system that simply plugs into our Flexibus® II backplane and supplies your system with an additional CPU, up to 8k of each of RAM and EPROM, 4 synchronous / asynchronous, full-duplex ports, memory mapped access to global memory, software controlled interrupt and TTL compatible logic, along with a bevy of communications adaptors that interface to practically any communication system you choose.

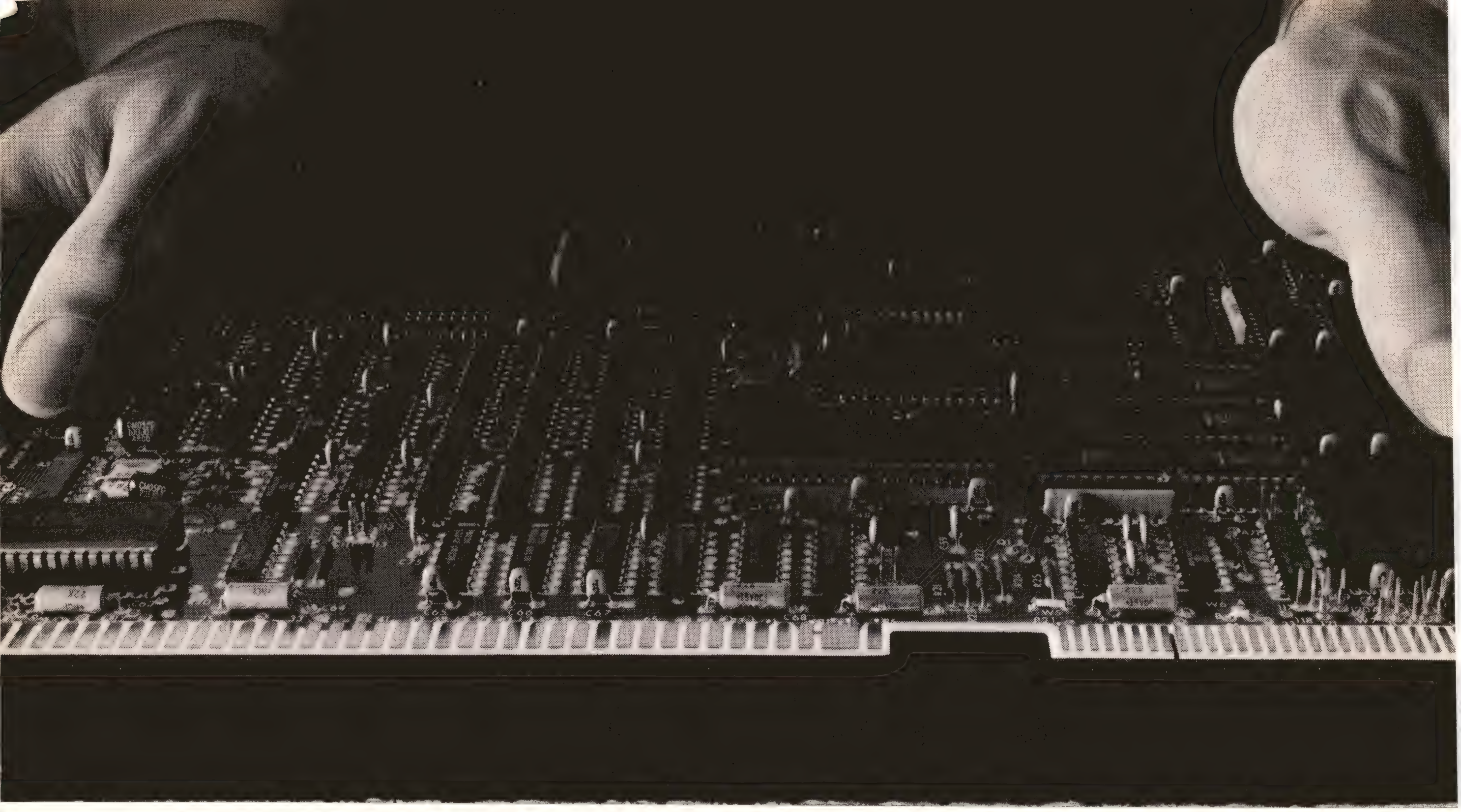
In addition, it supports user supplied software for HDLC, SDLC, BYSYNC, 2780/3780/3271/3275 emulation and for networks. On-board EPROM can be used to direct processor operation. Programs can be executed from local on-board memory or from global memory. The choice of an internal/external clock is jumper selectable for each port. Call it a slave computer, or a multiprocessor or intelligent I/O but always call your PCS representative or the PCS HOTLINE (313) 429-4971, and lets discuss just how our 1861A can solve your problem.



pcs

Process Computer Systems, Inc.
750 North Maple Road
Saline, Michigan 48176
(313) 429-4971 TWX: 810-223-8153

For more information, Circle No 203



RUN YOUR SYSTEM TEST BEFORE THE BOARD GOES IN THE SYSTEM.

To thoroughly test LSI boards, you have to test them at speed.

That used to mean testing them in the final product. But not any more.

Teradyne's L135 LSI Board Test System is designed to emulate full operation during board testing. Consider the advantages.

HIGHER YIELD.
HIGHER QUALITY.

Errors encountered testing a single board are far more easily located and corrected. Localizing problems during final product testing can take hours.

During board test, the L135's automatic diagnosis capability finds faults at speed. Faults that would take hours to locate manually following a full system test.

What's more, thoroughly qualifying all LSI boards individually greatly enhances final product quality. System test yields climb, as do profits.

EMULATING SYSTEM ENVIRONMENT.

First, you have to duplicate system speed, and the L135 does. Its 5-MHz test rate is equal to most of today's microprocessors.

Precise edge control is essential, as well. The L135 offers up to five edge delays programmable in one nanosecond increments.

In other words, the L135 has what it takes to board test LSI as if it were a system test. So you can locate and correct problems with the kind of speed that really boosts yields.

It all adds up to productivity which, with Teradyne's L135, is the bottom line.

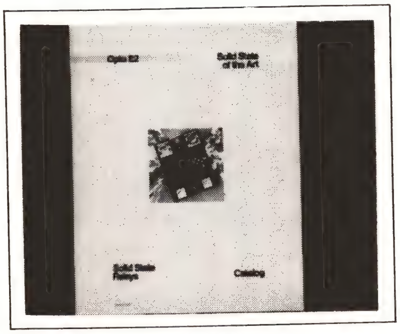
For more information on these and other L135 features, contact your local Teradyne Sales Office. Or call Teradyne Boston, (617) 482-2700.

PRODUCTIVITY IS THE BOTTOM LINE.

TERADYNE

For more information, Circle No 72

Literature



When to use solid-state relays

A fully illustrated catalog describes a complete line of solid-state relays, including ac-load and dc-load versions, chassis-mount and pc-board types, high-voltage transient-proof devices and the Liberator line, designed for high-volume OEM production. Catalog 679-1 provides applications information via a relay-selection guide; it details the relay types best suited for incandescent lamps, heaters, transformers, solenoid valves and contactors. **Opto 22,** 5842 Research Dr, Huntington Beach, CA 92649. **Circle No 468**

Conductive coatings for plastic enclosures

Covering the problems of improperly shielded plastic enclosures, this 8-pg brochure details the advantages of various organic conductive coatings in reducing EMI/RFI interference. It provides methods of coating plastics, coating requirements and aging data. Reliability information and a cost-effectiveness comparison of material, labor and cost/sq ft for various coating methods round out the paper. **Tecknit,** 129 Dermody St, Cranford, NJ 07016. **Circle No 469**

Operational-amplifier products guide

The opening section of this 12-pg op-amp reference describes the advantages of the manufacturer's dielectric-isolation process for fabricating high-performance analog ICs. A comprehensive selection guide covers high-slew-rate, wide-bandwidth, FET-input, low-power, dual high-performance, quad and special-purpose op-amp families. **Harris Semiconductor,** Dept 53-035, Box 883, Melbourne, FL 32901. **Circle No 491**

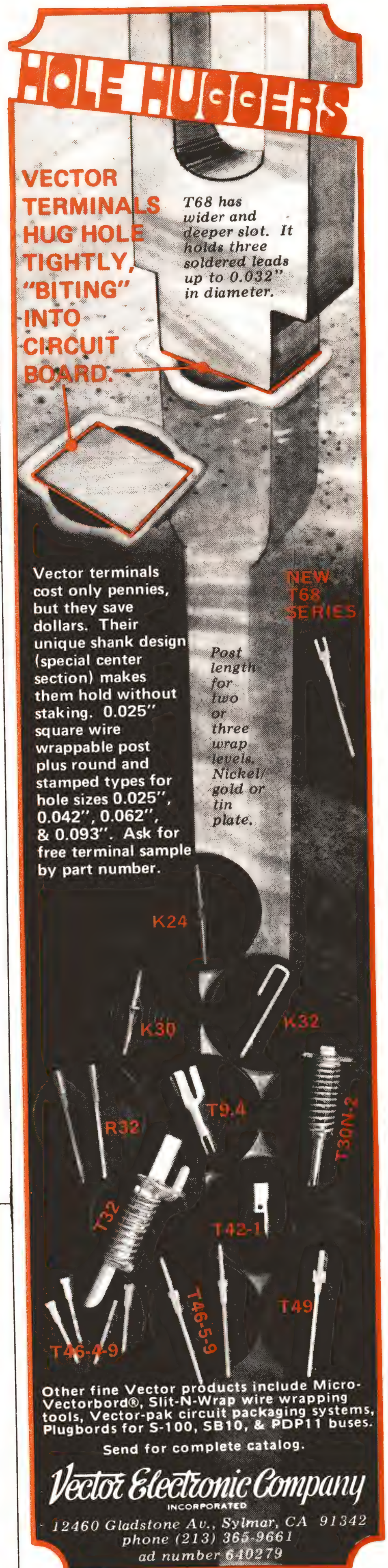
Full information on flat-cable system

According to this short-form catalog, components of the company's insulation displacement connector (IDC) flat-cable system are designed for high-speed assembly with low-cost tools. It contains material specs, dimensional drawings and complete ordering information on IDC socket connectors, headers, cable plugs and transition connectors. **Robinson-Nugent Inc,** 800 E Eighth St, New Albany, IN 47150. **Circle No 492**

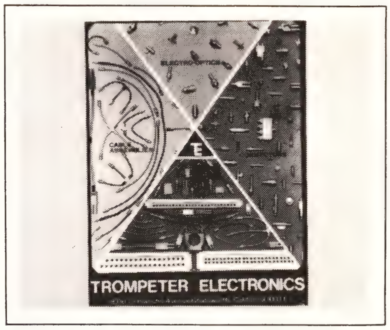
General-purpose and power relay catalog

Photos, specs and diagrams combine to describe more than 518 relay types for military, commercial, industrial and electronic uses. Along with application, packaging and mounting information, this 55-pg booklet includes details on UL-recognized, CSA-approved, multiple- and auxiliary-contact, hermetically sealed, enclosed plug-in, stud-mounted, switching and latching units, as well as indicators and test buttons. **Magnecraft Electric Co,** 5575 N Lynch Ave, Chicago, IL 60630. **Circle No 493**

See Page 96-97



Literature

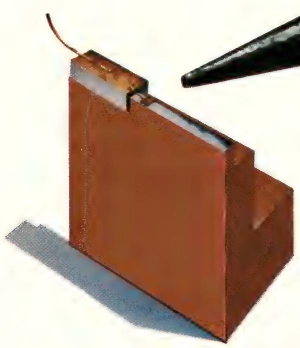


Products provide standard system-interface patches

Catalog T12 focuses on the company's broad line of patch panels, patch cords, cable assemblies, jacks, looping plugs, power dividers, RF connectors and electro-optical components. The first five pages of this 40-pg publication discuss how to determine the best methods of cabling, interconnecting and routing of signals to achieve minimum loss, degradation and noise pickup. **Trompeter Electronics Inc,** 8936 Comanche Ave, Chatsworth, CA 91311.

Circle No 494

In Semiconductor Lasers, Look To General Optronics...



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General Optronics sets the standard of design and performance for an entire industry ... with 100,000-hour lasers for unmatched reliability ... mass production capability and total application assistance.

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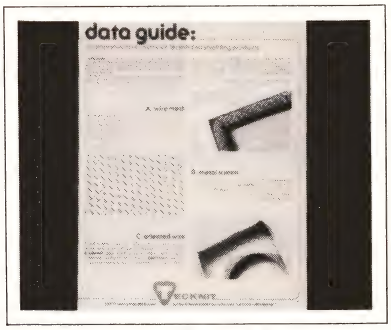
Illustrated Actual Size: Fiber Optic Transmitter ... Basic Laser Package ... Power Control Hybrid For Optical Instruments

For more information, Circle No 213

Literature



Guide provides assistance with shielding problems

The "Data Guide" serves as an initial aid and reference in the selection of this company's products for EMI-shielding, grounding and static-discharge applications. One page contains a shielding-materials selection guide in wall-chart form, which matches products with a broad range of materials and lists applicable data sheets. The publication also includes charts showing the shielding properties of various metals and how to avoid four common gasket-design errors. **Tecknit,** EMI Shielding Products Div, 320 N Nopal St, Santa Barbara, CA 93103.

Circle No 495

Electronic packaging products and services

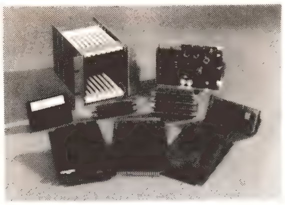
Catalog 108 includes dimensional information, detailed specs, wiring-service options and part-number matrices concerning the manufacturer's dual-in-line socket boards and hardware and wire-wrap cards. The software and wiring section details the data preparation required for automated wiring using the company's most popular wiring-service plans. **EECO,** 1441 E Chestnut Ave, Santa Ana, CA 92701.

Circle No 496

New products highlight test instrument booklet

Catalog BK-180 features more than 40 high-quality test instruments for engineering, production-line and other industrial applications. Each product description includes a photo, detailed specs and useful application information. New products in the 44-pg catalog include eight new scopes, a 5-MHz pulse generator, a variable-output isolation transformer and a 3½-digit DMM with LCD readout and 0.1% accuracy. **B&K-Precision,** Dynascan Corp, 6460 W Cortland St, Chicago, IL 60635.

Circle No 497



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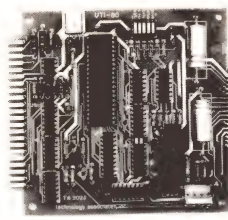
902 N. 9th St., Lafayette, IN 47904

For more information, Circle No 222



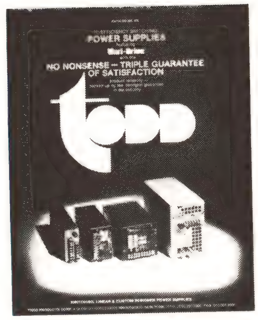
THERMAL PRINTER INTERFACE

NOW the Technology Associates UTI-80 allows immediate implementation of the Texas Instruments thermal printer assemblies achieving the advantages of silent operation, solid state reliability with a minimum of power consumption.

The microcomputer based 4¾" X 5½" board features a number of DIP switch selectable options. These include parallel or serial input: 100,300 or 1200 Baud, invert print, and self contained diagnostic. No additional external components are needed. A special cable and power supply are available as options.

TECHNOLOGY ASSOCIATES inc.
6620 TRAILWAY CIRCLE
P.O. BOX 276
PARKER, COLORADO
80134
(303) 841-3435

For more information, Circle No 223



NEW SWITCHING POWER SUPPLY CATALOG Full line of switching, linear, and custom power supplies featuring the hottest new product on the market, Todd's SM Series MultiSwitcher. The catalog also describes how VARI-DRIVE™, the big difference in switchers, solves basic switcher problems and improves switcher reliability. All Todd switchers have RFI filtering to meet VDE and MIL specs, are UL approved, and are backed by an exclusive 5 year triple guarantee. Todd Products Corp., 50 Emjay Blvd., Brentwood, NY 11717, 516-231-3366

For more information, Circle No 224

Literature

Magnetic pickups and digital transducers

A 28-pg catalog illustrates approximately 45 active and passive magnetic pickups designed for severe industrial environments, as well as digital-output transducers, shaft encoders, connectors and cable assemblies, split and solid gears, pickup mounting brackets, tachometer transducers and NEMA ring assemblies. In addition to specs, the booklet includes output-voltage charts and sensitivity curves. **Airpax,** 6801 W Sunrise Blvd, Ft Lauderdale, FL 33313.

Circle No 498

Do it yourself with electronic kits

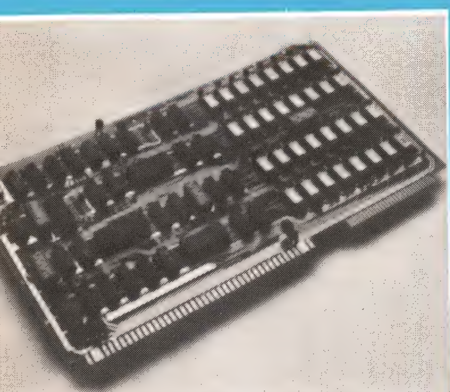
A 96-pg catalog describes kits for building amateur-radio equipment, color TVs, high-fidelity components, aircraft electronics, digital clocks, test instruments and personal computers. New products include programming languages and applications software for H8 computer, a dual high-frequency wattmeter and more continuing-education programs covering automotive electrical systems and test-instrument use. **Heath Co,** Benton Harbor, MI 49022.

Circle No 237

Method for solving coil-design problems

"Graphical Multilayer Coil Design Guide" offers a short cut to determining coil resistance for the entire range of available wire sizes. It shows how to eliminate the hit-or-miss approach of winding many trial coils until you achieve the desired coil parameters. The formulae, graphs and charts presented compare wire gauge to coil resistance, coil turns, power dissipation and ampere turns. **Magnecraft Electric Co,** 5575 N Lynch Ave, Chicago, IL 60630.

Circle No 238

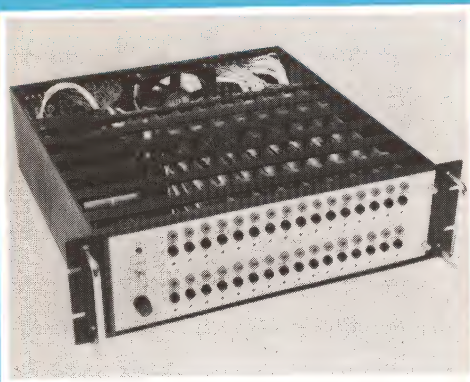


MEM-64/8+16 (byte swap) and RMEM-64/8⊕16 emory Boards feature 250 nanosecond access me, page switching option, on-board refresh and equential refresh.

- RMEM-64/8+16 are used with 8 and 16 bit bus masters. RMEM-64/8+16 allows 1 megabyte or ½ megaword addressability. ($1,600.00)
- RMEM-64/8⊕16 allows access in an 8-bit mode when strapped for an 8-bit processor; is also used in a 16-bit mode with 16-bit bus masters, and allows up to 1 megabyte of memory in byte mode, and 1 megaword of memory in word mode. ($1,700.00)

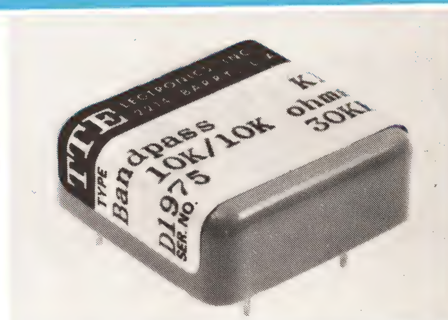
rder from RELMS, Relational Memory Systems, nc., 1180 Miraloma Way, Sunnyvale, CA 94086, 408) 732-5520 TWX 910 379 0014.

For more information, Circle No 225



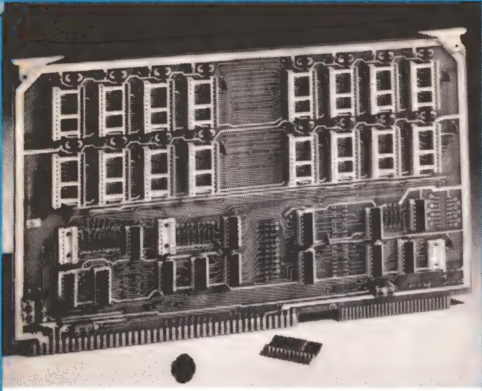
NEW LOW LEVEL INSTRUMENTATION AMPLIFIER SUBSYSTEMS specially designed high performance units can interface directly with PDI's 6000 & 7000 subsystems. Performance characteristics: high gains to 500; accuracy: 0.01%; linearity: 0.005%; very low gain; offset temp. coeff. & 2 pole Butterworth filter option. Std. 19" rack mount chassis with max. of 32 channels per chassis or 4 channels per card. Phoenix Data, Inc., 3384 W. Osborn, Phoenix, AZ 85017. PH 602/278-8528 TWX 910-951-1364

For more information, Circle No 226



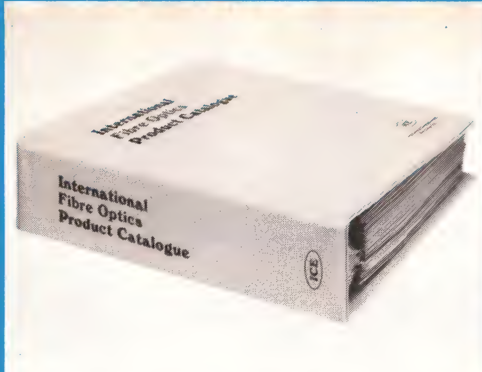
MINIATURE FILTERS for Highpass, Lowpass, Bandpass and Band Reject signal conditioning applications are described in the New Catalog. Flat passbands and sharp cut-offs are featured. Any frequency from 3Hertz to 300 Megahertz may be specified. These Filters are used in bio-medical, radar, analysis, modem, anti-aliasing, telemetry, sonar, seismic, control and many otner electronic systems to eliminate noise and harmonics without signal distortion. Many types are available from stock. **T T Electronics, Inc., 2212 Barry Ave., Los Angeles, CA 90064, (213) 478-8224.**

For more information, Circle No 227



SBC 80 Compatible 32K PROM board. The PROM-32 accepts sixteen 2716 E-PROMs. All IC's are socketed. The base addresses of the memory fall on 16K boundaries and are settable to 0000, 4000, 8000, and C000 Hex. Any 2K memory block may be deselected. This feature allows other boards to use the deselected address blocks. Best of all is our 3 yr warranty! $250 (Qty. 1-9). Stock. Electronic Solutions, Inc., 7969 Engineer Rd., San Diego, CA 92111. (714) 292-0242.

For more information, Circle No 228



International Fibre Optics Product Catalogue Over 500 pages of manufacturer and product specs, data sheets, supplier listings, and other information devoted exclusively to Fiber Optics. Catalogue provides complete update services for new products. Includes fibers, cables, light sources, detectors, connectors, data links, complete systems, measurement equipment, services, studies, components, couplers, optical modulators and more. I.C.E., Fiber Optics Div., P.O. Box 249, Southborough, Mass. 01772, (617) 485-7641

For more information, Circle No 229

SAMPLE LED LIGHTS

Get free samples of new Super-Brite L indicator lights from Industrial Devic Inc., Edgewater, N. J. 07020. Red, gre yellow, 100,000-hr. life. Low ac or power-drain, high reliability, shock-sistant. Fit 5⁄16" holes. Hemispheric or fl top. Ideal for solid-state and battery. C the-shelf for 6, 12, 24 volts.

For more information, Circle No 230

Literature

Reducing LSI devices' test-program development time

Entitled "Algorithmic Pattern Generation Techniques," a 12-pg booklet explains a method of algorithmically generating a truth table of LSI-device pin activity that can easily be checked and debugged by the test programmer. **Fairchild Systems Technology,** 1725 Technology Dr, San Jose, CA 95110. **Circle No 239**

Truly portable cesium time standard

Three pieces of technical literature include: a 6-pg cesium-standard performance comparison; a 4-pg brochure describing the FTS 4010 portable cesium clock; and a 4-pg leaflet detailing the specs and applications of the FTS 4000, which the company claims is the only modular cesium standard available in the US. **Frequency and Time Systems Inc,** 182 Conant St, Danvers, MA 01923. **Circle No 165**

Properties of materials at microwave frequencies

A wall chart shows the dielectric constant and dissipation factor (or loss tangent) of more than 140 common and uncommon materials by means of position on a grid chart. More than 140 substances are depicted. The 16½×11-in. chart lists some of this manufacturer's dielectric materials and also includes a section on definitions. Formulas relating permittivity, dielectric constant, index of refraction, loss factor, dissipation factor, power factor, attenuation and wave impedance complete the reference. **Emerson & Cuming Inc,** Canton, MA 02021. **Circle No 457**

Now you can increase the universality of your Intellec development system with four, new relocatable macro-assemblers from RELMS.
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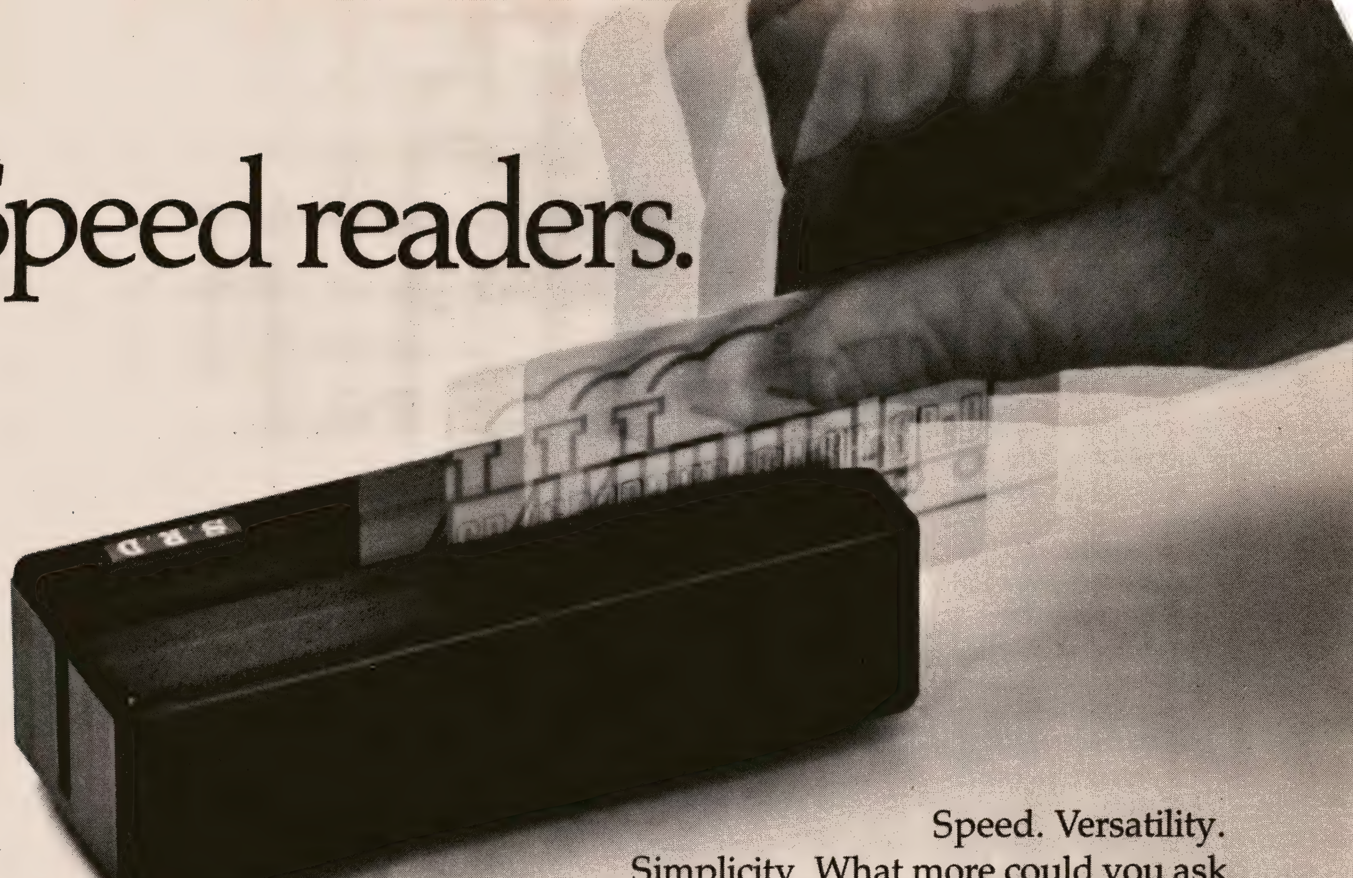
For more information, Circle No 233

Speed readers.



Speed. Versatility. Simplicity. What more could you ask from a mag card reader? C. Itoh thinks you should ask a lot more. Because we deliver a lot more. To begin with, every model of our MCR, MCR-250, MCE-202 and SRD series readers is fast and easy to use — most models read accurately at any speed from 3.9 all the way up to 59 IPS. Secondly, C. Itoh offers readers for virtually any application: read, write, read after write, read/write, single and multi-channel, and encoding are all available for ABA, MINTS and IATA standards. They're the perfect units for banking, POS, credit authorization, parking systems, inventory control, auto telephone dialing systems and literally scores of other applications. Whether slide type or insert, every one is designed to be rugged, reliable and durable — most models have a life of over 300,000 card passes, even under high-use, out-of-doors, and other adverse conditions. And a compact, lightweight design means that C. Itoh's mag card transports fit in just about anywhere. Fast, versatile, simple, reliable, durable, compact — that should be enough for any mag card reader. But C. Itoh gives you one more very special benefit. A low price.

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For more information, Circle No 234

A UNIQUE CHOICE OF DATA ACQUISITION SYSTEMS FOR THE LSI-11/2 AND 11/23. NOW FROM ADAC.

When it comes to data acquisition systems, there is nothing quite like the ADAC System 1000 and the new System 2000.

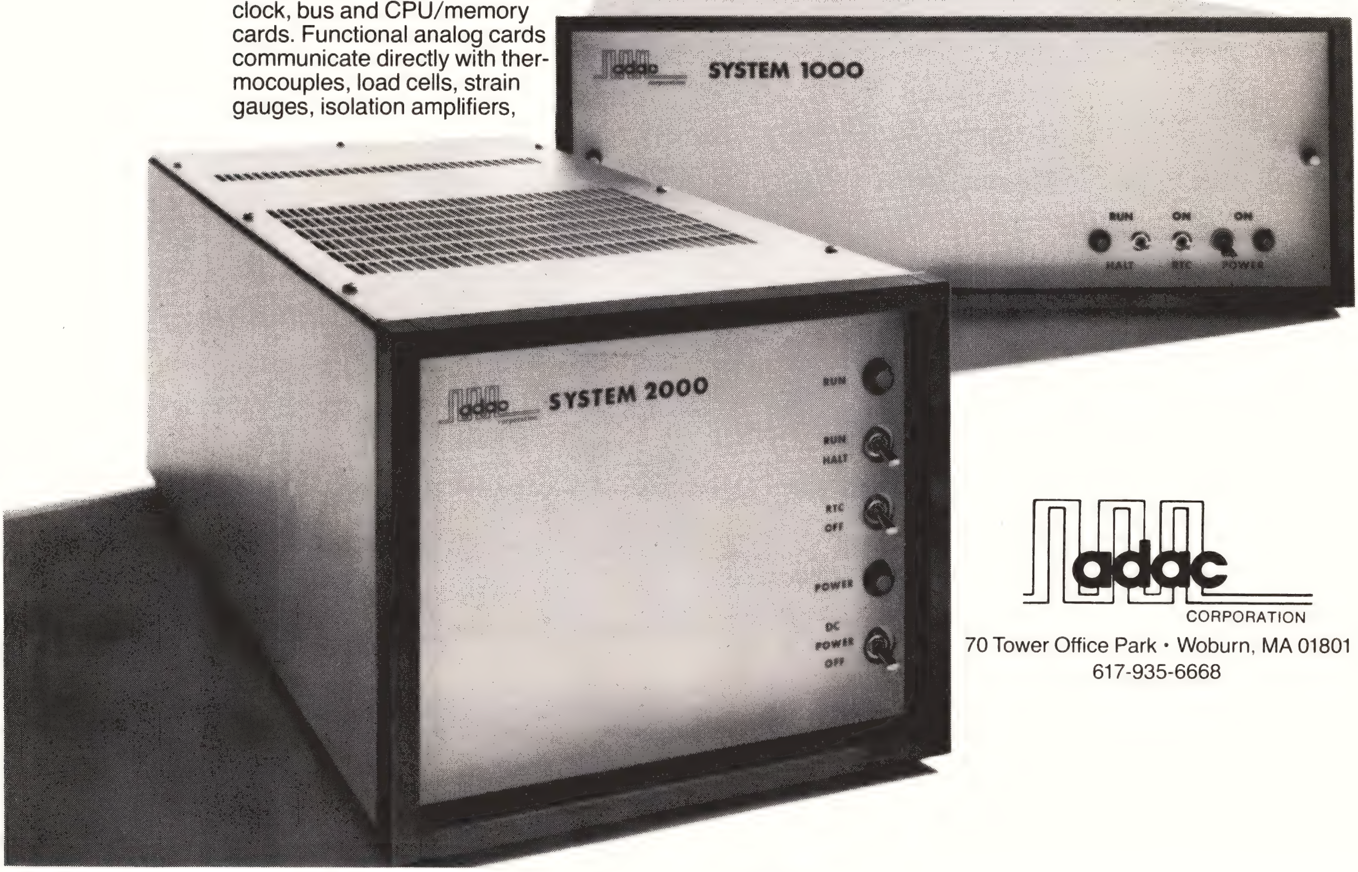
Both systems can operate as low cost peripheral expanders to any UNIBUS computer. When incorporating a DEC LSI-11/2 or 11/23 microcomputer the systems operate as stand alone control systems or as remote intelligent terminals.

The compact System 2000 is built to hold 13 half quad cards. If you need greater capacity, slave units can be utilized or you can go to the larger System 1000 which accommodates any combination of 11 quad size cards or 22 half quad size cards. Both systems can be bench top or rack mounted and have a universal power supply that can support up to 256 kilobytes of memory.

The real heart of both System 1000 and System 2000 is their incredible number of analog, digital, serial I/O, clock, bus and CPU/memory cards. Functional analog cards communicate directly with thermocouples, load cells, strain gauges, isolation amplifiers, transmitters and strip chart recorders to name a few. Discrete cards communicate with switch contacts, relays, thumb wheel switches, pumps, motors and other devices. All cards can be purchased as separate items.

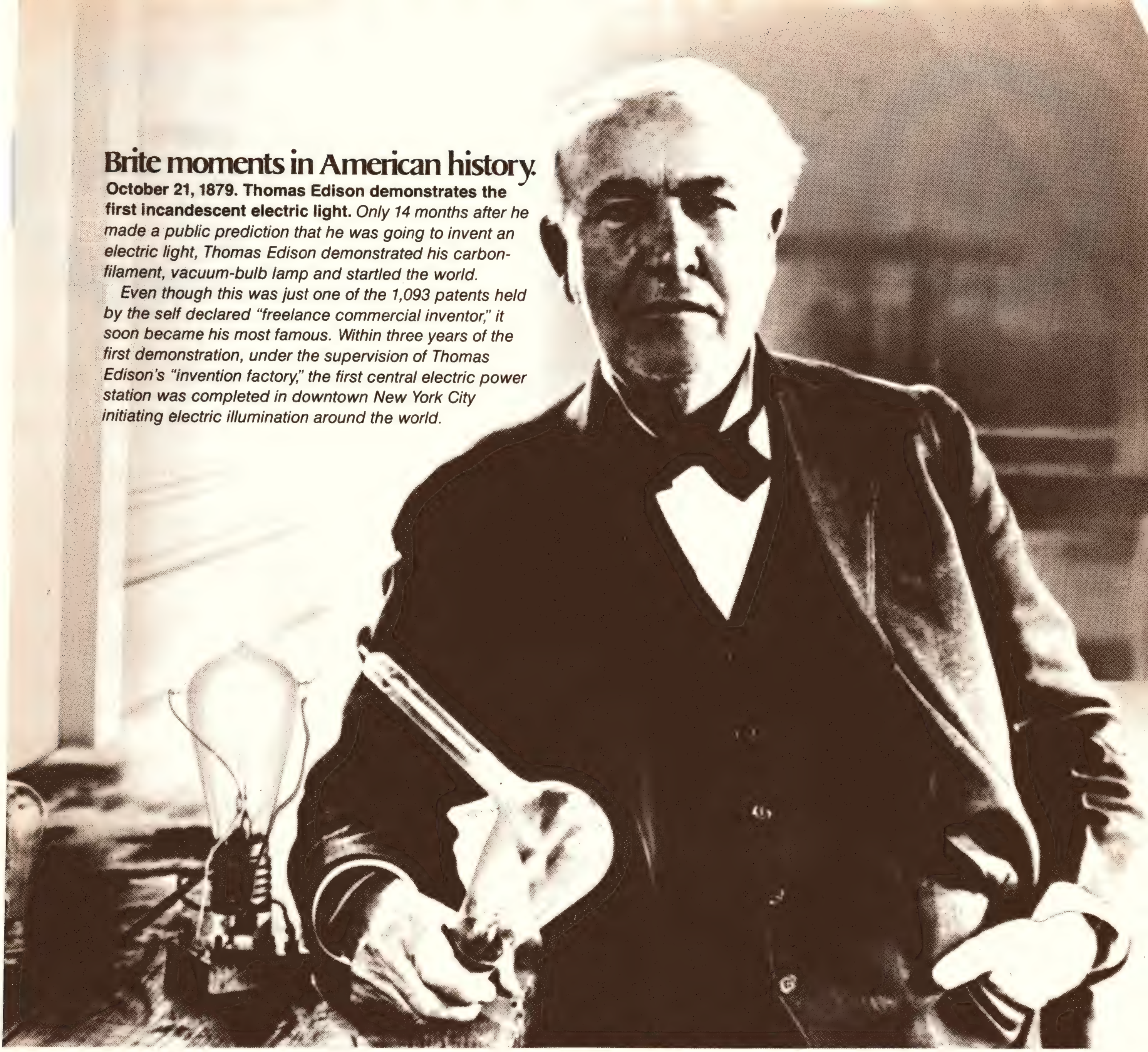
A single System 1000 can be supplied with up to 700 high level analog input channels, or 128 analog low level input channels, or 700 digital I/O functions. A typical System 2000 contains a CPU, 64 kilobytes of memory, floppy disc controller, 16 channel A/D, 4 channel D/A, 32 TTL I/O lines, two serial I/O ports plus room for another six cards of your choice.

Another nice thing about both systems is their prices. They start at $995 for the System 2000 and $1550 for the System 1000. So you can choose the combination of price and capability that's just right for your application. Contact ADAC for full details.



adac
CORPORATION
70 Tower Office Park • Woburn, MA 01801
617-935-6668

For more information, Circle No 235



Brite moments in American history.

October 21, 1879. Thomas Edison demonstrates the first incandescent electric light. *Only 14 months after he made a public prediction that he was going to invent an electric light, Thomas Edison demonstrated his carbon-filament, vacuum-bulb lamp and startled the world.*

Even though this was just one of the 1,093 patents held by the self declared "freelance commercial inventor," it soon became his most famous. Within three years of the first demonstration, under the supervision of Thomas Edison's "invention factory," the first central electric power station was completed in downtown New York City initiating electric illumination around the world.

Photograph Courtesy of the National Archives

The All-American Brite-Lite.®

They're a far cry from incandescents. Our Brite-Lite LED lamps are proven many times brighter than other LED's giving you the same level of brightness as incandescents. At the same time, they're proven to last at least 10 times longer, while using only half the power. Brite-Lites give you solid-state reliability, not filament frailty.

Another thing on our side is we are a company that only manufactures in America. This way, you never have to wait for overseas shipments to arrive, which just may be the second reason, after reliability, why Brite-Lites are the number one choice over any other LED lamps available.

Whether you're looking for red, green or amber, transparent or translucent, 1.6 or 48 volts, 10 or 35 milliamps, midget flanged snap-ins or space-saving PC lites—or any combination of the above—you've come to the right place. For the All-American Brite-Lite.

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Looking Ahead: Trends and Forecasts

Opportunities seen in China trade for US

Although analysts disagree on the size of China's potentially vast electronics market (EDN, August 5, pg 194), some of them see realistic opportunities for sales of high-quality peripherals, communications and test equipment, process controls and consumer products by US firms.

The Chinese will buy floppy and hard discs, tape units and nonimpact or matrix impact printers (preferable to chain/train or drum types because of the Chinese alphabet's complexity), according to Ken Bosomworth, president of International Resource Development Inc, Norwalk, CT. (Japanese competition will be fierce in these markets, however). Bosomworth also sees possible sales of intelligent and specialized terminals, including those with so-ohisticated graphics capabilities.

Satellites, fiber-optic transmission systems and pulse-:ode-modulation technology will)e important in the communica-ions market. China, however, vill supply its vast consumer narket by buying complete)roduction facilities (for such)roducts as color TVs and ·ideotape recorders), limiting .ny long-term export potential n this area.

China could account for 1 to % of the sales of a firm with uperior products, says Jerry ,evine, president of Mentor nternational, San Francisco. ;ut Levine, who recently isited China, advises compa-ies to realistically assess the robability of sales before xpending time or money in 'hat could be a disappointing enture. Products considered)r export should meet the following criteria: exportable under US Export Administration regulations, categorized as nonconsumable equipment rather than components (prime examples: production, test, telecommunications, and data-processing equipment; test and measuring instruments; process controls) and superior in quality and/or performance to Japanese or European products.

The creation of the China International Trust Investment Co to coordinate the use of foreign investment and technology and the recent enactment of a joint-venture law for foreign investments could spur sales by US firms. (Compensation required by the new law "in cases of losses caused by deception through the intentional provision of outdated equipment or technology" underscores China's concern about not being sold outdated equipment.) A further positive development: Despite a slowing of its modernization program and a retrenchment in some areas of the economy, China has reserved \$3.03 billion in its \$72.3 billion 1979 state budget for acquiring technology and capital equipment, out of a projected \$16 billion in total imports.

US OEM printer market near \$930.5M by 1981

High-volume OEM printer sales in the US will increase from \$505.5 million last year to \$930.5 million in 1981, forecasts International Data Corp, Waltham, MA.

While impact printers should nearly double their installed base during these 3 yrs (from 149,200 to 270,500), nonimpact units will experience the greatest growth, doubling their installed base this year alone and reaching 150,500 installed units by 1981.

% GROWTH			
PRINTER TYPE	1979	1980	1981
IMPACT			
CHARACTER	21	17	16
SERIAL (MATRIX)	15	14	10
LINE	35	26	22
TOTAL	27%	21%	18%
NONIMPACT			
ELECTROSTATIC	22	14	8
THERMAL	100	78	48
INKJET	425	337	138
OTHER	65	30	21
TOTAL	97%	77%	62%

SOURCE: INTERNATIONAL DATA CORPORATION

Having plunged 20 to 50% over the past decade, printer prices will continue to drop for all units except inkjets, whose prices will rise as higher resolution models are introduced.

\$14 billion in IC sales predicted for 1988

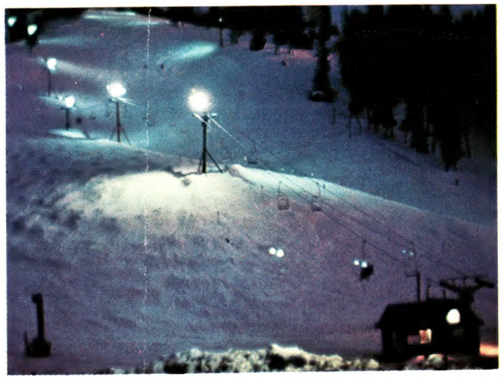
Explosive integrated-circuit demand will drive US semiconductor sales from \$3 billion last year to \$14 billion by 1988, according to Arthur D Little Inc, Cambridge, MA.

Fueled by significant growth in traditional applications such as computers, peripherals, communications and consumer products, as well as by new applications in areas such as automotive equipment and appliances, the industry will grow 15 to 20% annually, with the worldwide market reaching 1 trillion units per year by 1990.

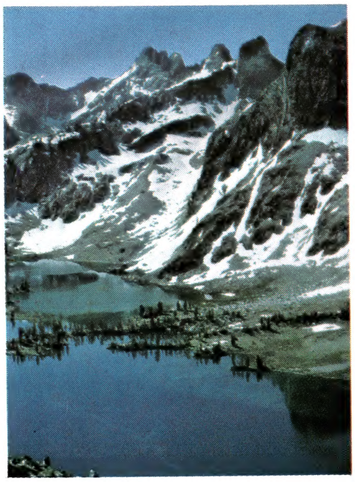
Increased capacity and automation should alleviate shortages and reduce long leadtimes over the next decade. And fears of political instability and rising labor costs in some offshore areas will drive manufacturers toward complete domestic production by the mid-1980s.

Material for this page developed from *Electronic Business* magazine and other sources by Jesse Victor, Senior Copy Editor, and Joan Morrow, Editorial Assistant.

Experienced Engineers...
...how about Hewlett·Packard in Idaho?



Hewlett-Packard's Disc Memory and Boise Divisions are located in Boise, the state capital of Idaho. Boise is the largest city in Idaho and has a growing area population of approximately 175,000. Due to its strategic location, Boise's Treasure Valley has the distinction of being a regional center for transportation, commerce, finance and industry for the Northwest. For this reason, Boise is attracting an ever-increasing number of businesses, visitors and residents. Boise's temperate, seasonal climate offers a variety of weathers from mild winter snowfalls to sunny summer days which promote year-round sports, shopping, sight-seeing and dining. Boiseans have the benefit of a philharmonic orchestra, community theaters, art exhibitions and local performing groups such as the Basque "Oinkari" dancers. Boise has retained a reasonable cost-of-living and an affordable housing market.



Idaho is a vast natural year-round recreational area. Alpine and cross-country skiing are conveniently located throughout the state. Bogus Basin, only 15 miles from downtown Boise, has two major mountains providing more than 30 groomed runs, excellent powder conditions and good night skiing with 11 lighted runs. With a multitude of lakes and rivers, Idaho is a prime attraction for rafters, water skiers and fishing enthusiasts. Idaho's mountainous regions are irresistable to the avid backpacker and hunter.

Hewlett-Packard in Boise consists of two divisions which occupy several recently constructed buildings on a 180-acre site overlooking the Boise River valley. By 1980 two additional buildings will be completed, including major fabrication and technology centers. Our continued growth has resulted in several openings for experienced engineers who are proven contributors.

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